

STS-86 SPACE SHUTTLE MISSION REPORT

November 1997



**National Aeronautics and
Space Administration**

**Lyndon B. Johnson Space Center
Houston, Texas**

NOTE

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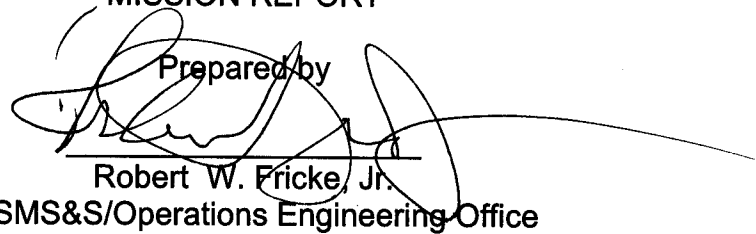
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STS-86

SPACE SHUTTLE

MISSION REPORT

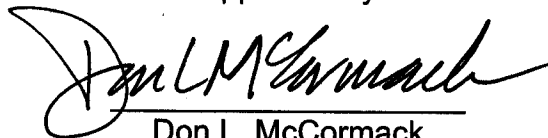
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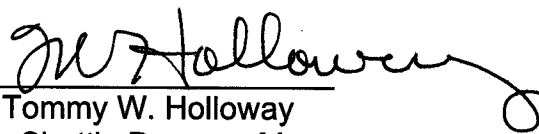
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INTRODUCTION

The STS-86 Space Shuttle Program Mission Report presents a discussion of the Orbiter subsystem operation and the in-flight anomalies that were identified during this seventh Mir rendezvous mission. The report also summarizes the mission activities and presents a summary of the External Tank (ET), Solid Rocket Booster (SRB), Reusable Solid Rocket Motor (RSRM), and Space Shuttle main engine (SSME) performance during this eighty-seventh mission of the Space Shuttle Program. STS-86 was the sixtieth flight since the return to flight, and the twentieth flight of the OV-104 (Atlantis) Orbiter vehicle.

The flight vehicle consisted of the OV-104 Orbiter; an ET that was designated ET-88; one block 1 and two Phase II SSMEs that were designated as serial numbers (S/N) 2012 (Phase II), 2040 (Block I), and 2019 (Phase II) in positions 1, 2, and 3, respectively; and two SRBs that were designated BI-090. The two RSRMs were designated RSRM 061 with one installed in each SRB. The individual RSRMs were designated 360T061A for the left SRB, and 360T061B for the right SRB.

The STS-86 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirements as documented in NSTS 07700, Volume VIII, Appendix E. The requirement is that each organizational element supporting the Program will report the results of their hardware and software evaluation and mission performance plus identify all related in-flight anomalies.

The primary objectives of the STS-86 flight were to rendezvous and dock with the Mir Space Station, and perform the exchange of a Mir astronaut. A Spacehab double module carried science experiments and hardware, Risk Mitigation Experiments (RMEs) and Russian Logistics in support of the Phase 1 Program requirements. In addition, a U. S.-only extravehicular activity (EVA) was performed and included the retrieval of the Mir Environmental Effects Payload (MEEP) and the evaluation of EVA hardware. Also, Cosmic Radiation Effects and Activation Monitor (CREAM) payload operations were performed. Secondary objectives of this flight were to perform the requirements of KidSat, Commercial Protein Crystal Growth (CPCG) Cell Culture Module Configuration A (CCM-A) and Seeds in Space-II (SEEDS-II); and as payloads of opportunity, the Midcourse Space Experiment (MSX) and Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX).

The STS-86 mission was a planned 10-day plus 1-day plus 2-contingency-day mission during which logistics for the Mir station would be transferred and experiments would be performed. The plus-1 day provided an opportunity for docking on flight day 4 should the phasing angle or other problems have prevented the docking on flight day 3. The two contingency days were available for bad weather avoidance for landing, or other Orbiter contingency operations. There was six docked days with the Mir.

The STS-86 sequence of events is shown in Table I, the Space Shuttle Vehicle Engineering Office (SSVEO) In-Flight Anomaly List is shown in Table II, and the EVA anomaly is shown in Table III. Appendix A lists the sources of data, both informal and formal, that were used in the preparation of this report. Appendix B provides the definitions of all acronyms and abbreviations used in this report. All times are given in Greenwich mean time (G.m.t.) and mission elapsed time (MET).

The eight crewmembers of the STS-86 mission consisted of James D. Wetherbee, CDR, U. S. Navy, Commander; Michael J. Bloomfield, Major, United States Air Force, Pilot; Vladimir Georgievich Titov, Colonel, Russian Air Force, Mission Specialist 1; Scott E. Parazynski, M. D., Civilian, Mission Specialist 2; Jean-Loup J. M. Chretien, Brig. General, French Air Force, Mission Specialist 3; Wendy B. Lawrence, CDR, U. S. Navy, Mission Specialist 4; David A. Wolf, M. D., Civilian, Mission Specialist 5 (ascent through crewmember transfer to the Mir); and C. Michael Foale, Ph. D., Civilian, Mission Specialist 5 (crewmember transfer from the Mir through landing). STS-86 was the fourth Space Shuttle space flight for the Commander and Mission Specialist 5 (descent), the second Space Shuttle space flight for Mission Specialist 2, Mission Specialist 4, and Mission Specialist 5 (ascent) and the first Space Shuttle space flight for the Pilot. STS-86 was also the second Space Shuttle flight for Mission Specialist 1; however, he had flown three times on the Soyuz, one of which was to the Mir Space Station where he spent over 365 days before returning to Earth. This was the first Space Shuttle flight for Mission Specialist 3; however, he had two successful flights on the Soyuz, one to the Salyut 7 and the second to the Mir Space Station where he spent over 24 days performing experiments plus participating in almost a 6-hour EVA.

MISSION SUMMARY

The STS-86 mission was launched at 269:02:34:19.000 G.m.t. (10:34 p.m. e.d.t. on September 25, 1997) after a satisfactory countdown with no unplanned holds. The start of liquid hydrogen (LH₂) loading was delayed approximately 1 hour 30 minutes because of a LH₂ loading software problem.

A determination of vehicle performance was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (Isp) determined for the time period between SRB separation and start of 3g throttling was 452.27 seconds as compared to the main propulsion system (MPS) tag value of 453.05 seconds. Main engine cutoff (MECO) occurred 510.870 seconds after liftoff.

The fuel cell 2 substack cell performance monitor (CPM) differential voltage output was erratic for approximately 61 seconds starting at 269:02:35:21 G.m.t. (00:00:01:02 MET). The CPM reached its off-scale-high value of 500 mV for two seconds starting at 269:02:35:37 G.m.t. (00:00:01:18 MET) (Flight Problem STS-86-V-01). After 61 seconds, the output returned to the normal 6 to 8 mV range. Because of this ascent event, main busses A and B were bus tied at 269:02:46 G.m.t. (00:00:11 MET), and as a precaution, the bus tie remained until deorbit preparations were initiated. The CPM performed nominally for the remainder of the mission, as well as the fuel cell 2 substack 1 differential voltage remaining in the 2 to 8 mV range.

Primary reaction control subsystem (RCS) thruster L3D failed off during its first commanded firing following ET separation (Flight Problem STS-86-V-02). During the firing, the chamber pressure (P_c) did not rise above 4 psia, and the thruster was deselected due to the low P_c indication. The L3D injector temperature data profile was indicative of a normal firing suggesting that the thruster did fire. Data review showed that the L3D P_c slowly decreased from approximately 18 psia to 4 psia over a 7-minute period during ascent, whereas the drop should have occurred in approximately 1.5 minutes. The data from ascent and the ET separation firing indicate that the cause of the condition may have been a plugged P_c tube. The thruster remained deselected for the remainder of the mission.

The orbital maneuvering subsystem (OMS) 1 maneuver was not required as the direct ascent trajectory was flown. The OMS 2 maneuver was performed satisfactorily at 269:03:16:09 G.m.t. (00:00:41:50 MET). The maneuver was 108.2 seconds in duration and provided a differential velocity (ΔV) of 171.6 ft/sec. The resultant orbit was 161 by 139 nmi.

The payload bay doors were opened at 269:04:07:48 G.m.t. (00:01:33:29 MET). Nominal subsystem operation was noted during the door-opening sequence.

The second OMS maneuver (OMS 3) was a dual engine, straight-feed firing, and the resultant orbit was 200.9 by 150.8 nmi. Data indicated nominal OMS performance.

Fuel cell amperes indicated an 80-ampere spike for 0.3 second at 269:07:40 G.m.t. (00:05:05 MET). Data indicate that the load was probably on main bus B. Items powered directly from the main busses are the crew cabin panel buses, which includes the utility outlets, the middeck utility panel (MUP), and the power reactant storage and distribution (PRSD) tank heaters. The crew reported that circuit breaker CB4 on the

MUP was open. CB4 supplied power to the two payload and general support computers (PGSCs) for the Global Positioning System (GPS)/ Inertial Navigation System (INS) Development Test Objectives (DTOs) 700-12 and 700-15. A continuity check of the Y- cable providing power to the computers yielded nominal results. After checks of the Orbiter power jack to determine the cause of the CB4 trip showed no problem with the cable, the crew reset CB4 and verified correct voltages from the power outlet.

The investigation into the PGSCs used for DTO 700-12 (Litton GPS/INS) and DTO 700-15 [Space Integrated GPS/INS (SIGI)] showed problems to be present in both PGSCs. Multimeter measurements taken by the crew indicated that the DTO 700-15 PGSC had a shorted condition between the power plug and the chassis ground. This was the cause of the current spike. Workarounds for DTOs 700-12 and 700-15, as well as their flight performance are discussed in the Development Test Objective section of this report.

At 269:17:26 G.m.t. (00:14:51 MET), the OMS 4 (NC2) dual-engine, straight-feed maneuver was initiated, and the resultant orbit was 209 by 176 nmi. Data from this maneuver showed nominal performance from both engines.

Extravehicular mobility unit (EMU) checkout of both suits in preparation for the EVA was performed with no anomalies. A battery recharge was performed on both units as well as a checkout of the heated gloves and both simplified aid for EVA rescue (SAFER) units.

The ODS was powered up for the docking ring extension at 270:00:38 G.m.t. (00:22:04 MET). The docking ring was extended at 270:00:42 G.m.t (00:22:08 MET) in preparation for the docking. The ODS performed nominally within dual motor times throughout the docking-ring extension procedure.

The +X NC3 maneuver was performed using the RCS at 270:03:22 G.m.t. (01:00:47 MET). The RCS performed nominally for this maneuver as well as all of the planned RCS rendezvous maneuvers. The table on the following page lists the OMS and RCS maneuvers, as well as the pertinent parameters, that were performed to complete the rendezvous with the Mir Space Station.

All Orbiter subsystems performed nominally during the successful rendezvous and docking with the Mir Space Station. The ODS avionics hardware performed nominally throughout the docking sequence with the one minor exception. The ODS heater no. 2/DCU power-indication toggling-off problem that was seen on previous missions (STS-76, STS-81 and STS-84) recurred. The problem also recurred when the ODS was used for the undocking. Capture occurred nominally at 270:19:57:46 G.m.t. (01:17:22:46 MET). The structural hooks were closed and docking was completed at 270:20:06:05 G.m.t. (01:17:3 MET). The loads and mechanism performance during the docking sequence were nominal. The crew exchange occurred at 271:16:34 G.m.t. (02:14:00 ET) when the transfer of the individual equipment liner kits (IELKs) for the Soyuz spacecraft were completed.

RENDEZVOUS MANEUVERS

Maneuver	Time, G.m.t./MET	ΔV , ft/sec	Duration, seconds
OMS 2	269:03:16:09 G.m.t. 00:00:41:50 MET	171.6	108.7
NC1/OMS 3	269:05:59:09 G.m.t. 00:03:24:50 MET	94.4	59.12
NC2/OMS 4	269:17:26:15 G.m.t. 00:14:51:56 MET	57.5	36.8
NC3/RCS	270:03:22:20 G.m.t. 01:00:48:01 MET	4.4	18
NPC	Not done	-	-
NC4/OMS 5	270:15:59:25 G.m.t. 01:13:25:06 MET	42.7	26.3
NCC/RCS	270:16:34:13 G.m.t. 01:13:59:54 MET	1.6	7
TI/RCS	270:17:31:55 G.m.t. 01:15:57:36 MET	5.6	23
MC1/RCS	270:17:41:13 G.m.t. 01:15:06:54 MET	0.2	1
MC2/RCS	270:18:25:13 G.m.t. 01:15:50:54 MET	1.3	5
MC3/RCS	270:18:42:13 G.m.t. 01:16:07:54 MET	1.2	5
MC4/RCS	270:18:52:13 G.m.t. 01:16:17:54 MET	1.2	5

In preparation for the EVA, the airlock depressurization began at 274:17:15 G.m.t. (05:14:40 MET) and was terminated at 274:17:32:29 G.m.t. (05:14:58:10 MET) without any problems. The EVA began when the crew members placed their EMU power switch to the battery position at 274:17:29 G.m.t. (05:14:54 MET). Astronaut Scott Parazynski (EV1) and Cosmonaut Vladimir Titov (EV2) successfully completed the scheduled EVA and retrieved the previously placed Mir environmental effects payload (MEEP) hardware, and completed an evaluation of the EVA hardware. The EVA ended with the start of repressurization at 274:22:30:02 G.m.t. (05:19:55:02 MET). The EVA duration was 5 hours 1 minute.

At the beginning of the EVA, the EV1 crewmember reported that the starboard safety tether reel would not retract. He reported that there was some tension when pulling the wire out of the reel, the lock/unlock lever moved freely in either direction, and the plunger at the base of the lock/unlock lever was not visible (Flight Problem STS-86-X-01). The reel was stowed in the airlock and returned to the crew cabin at the end of the EVA. Following the EVA, the crew reported that the reel began functioning normally after being in the cabin approximately 15 minutes. The plunger at the base of the lock/unlock lever was visible.

A repressurization of the Orbiter/Mir vehicle was started at 275:01:52 G.m.t. (05:23:18 MET) using PCS 1 to provide the N₂, PCS 2 to provide the O₂ and the direct O₂ valve open. The N₂ flow rate decreased to low flow 43 minutes later at a cabin pressure of 14.3 psia (Flight Problem STS-86-V-05) as the regulator transitioned from high to low flow. The repressurization was terminated by the crew at 275:02:40 G.m.t. (06:00:06 MET). The crew reported that ice had formed on the PCS panel. Typically,

the regulator would not have transitioned from high to low flow until the pressure had reached 14.5 to 14.6 psia.

Repressurization of the Orbiter/Mir vehicle from 14.3 to 14.62 psia using PCS 2 was initiated at 275:13:02 G.m.t. (06:10:28 MET) and was completed at 275:13:34 G.m.t. (06:11:00 MET). Cabin pressure was then raised from 14.62 to 14.7 psia using PCS 1 beginning at 275:13:34 G.m.t. (06:10:59 MET) and finishing at 275:14:25 G.m.t. (06:11:50 MET). Both PCS regulators performed nominally. After the N₂ pressurization was complete, O₂ repressurization was begun using the repressurization restrictor. The O₂ repressurization was terminated at 275:22:04 G.m.t. (06:19:30 MET) at a cabin pressure of 15.10 psia.

Initial indications are that the long duration high-flow rate (approximately 187 lb/hr) of N₂ flow through the cabin regulator chilled the regulator enough to cause the early transition from high flow to low flow.

During the Mir Space Station transfer operations, a total of 8,723 lb consisting of 303 transfer items, were delivered to the Mir. In addition, the Orbiter consumables that were provided were approximately 1717 lb of potable water, 75.7 lb of O₂, 130.1 lb of N₂ and eight canisters of lithium hydroxide (LiOH).

The ODS hatch was closed at approximately 275:23:06 G.m.t. (06:20:31 MET). Following hatch closure, the vestibule depressurization began at 275:23:17 G.m.t. (06:20:42 MET) and was completed 12 minutes later.

The ODS performed nominally during the undocking of the Orbiter with the Russian Mir Space Station. The ODS was powered up at 276:15:51:12 G.m.t. (07:13:16:53 MET). The structural hooks were activated in the open direction and the travel from approximately 92 percent to 6 percent was satisfactory and the structural hooks were deactivated. The undocking-complete signal was received at 276:17:28:15 G.m.t. (07:14:53:56 MET), and the ODS was powered down about 8 minutes later.

Following the undocking, the Orbiter backed away from the Mir to 600 ft. and evaluated the operation of the Risk Management Experiment (RME) 1314 European Space Agency (ESA) Proximity Operations Sensor (EPS). After completion of the successful test of the EPS, the Orbiter re-approached the Mir to within approximately 200 ft to perform a fly-around and damage survey of the Spektr module. The inspection revealed a possible damage site where Mir atmosphere was escaping. The RCS separation maneuver was performed at 276:22:25 G.m.t. (07:19:51 MET).

The OMS 6 two-engine straight-feed firing was initiated at 276:22:25:27.2 G.m.t. (07:19:51:08.2 MET) and was completed 19.6 seconds later resulting in a ΔV of 32.5 ft/sec.

The flight control subsystem (FCS) checkout was performed using APU 1. The FCS, APU 1 and hydraulic system 1 performed nominally during the checkout. APU 1 was started at 277:15:49:40.072 G.m.t. (08:13:15:40.072 MET) and ran for 6 minutes 20.849 seconds with a fuel consumption of 16 lb. No gearbox repressurizations occurred during the run, and no WSB operation occurred due to the short APU run time.

The RCS hot-fire was performed immediately following FCS checkout. All primary thrusters fired nominally during the hot-fire, except for L3D which failed off during External Tank separation as discussed earlier in this report.

The OMS 7 maneuver was performed in support of Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) at 277:20:32:14.2 G.m.t. (08:17:57:55.2 MET) using the left orbital maneuvering engine in straight-feed. The firing duration was 10.2 seconds with a resultant ΔV of 8.3 ft/sec.

The payload bay doors were closed and latched for landing at 278:19:16:34 G.m.t. (09:16:42:34 MET). The first landing opportunity at the Kennedy Space Center (KSC) Shuttle Landing Facility (SLF) was waved off because of unsatisfactory weather conditions.

At 278:21:59 G.m.t. (09:19:25 MET), during the time period between the first and second landing opportunities, the WSB 3 vent temperature decreased to off-scale-low (122 °F) (Flight Problem STS-86-V-06). Nominally, the heater should have cycled on at approximately 145 °F. The system had been operating on the B controller for over three hours when the data indicated that the B heater had failed off. At 278:22:28 G.m.t. (09:19:54 MET), WSB 3 was switched to the A controller and a rise in the vent temperature was observed a short time later. Following the second landing wave-off at 278:23:32 G.m.t. (09:20:58 MET), the B controller was reselected. The WSB 3 vent temperature did not recover above 122 °F. This same problem was seen during deorbit preparations on STS-76 (OV-104) and it subsequently recovered during that mission. STS-76 postflight troubleshooting did not isolate the problem, and the problem did not recur during STS-79, STS-81, or STS-84.

The second KSC landing opportunity on the planned landing day was also waved off because of unsatisfactory weather conditions. The payload bay doors were reopened at approximately 278:23:43:45 G.m.t. (09:21:09:26 MET).

The payload bay doors were closed for the second time at 279:18:06:30 G.m.t. (010:15:32:11 MET). The dual-engine deorbit maneuver for the first landing opportunity on the first contingency landing day at the SLF runway 15 was performed on orbit 169 at 279:20:47:45.3 G.m.t. (10:18:13:26.3 MET). The maneuver was 195.4 seconds in duration with a ΔV of 344.3 ft/sec.

Entry was completed satisfactorily, and main landing gear touchdown occurred on KSC concrete runway 15 at 279:21:55:12 G.m.t. (10:19:20:53 MET) (5:55 p.m. e.d.t. on October 6, 1997). The nose gear touchdown occurred at 279:21:55:19 G.m.t. and the Orbiter drag chute was deployed at 3.1 seconds later. The drag chute was jettisoned at 279:21:55:56.7 G.m.t. with wheels stop occurring at 279:21:56:31 G.m.t. The rollout was normal in all respects. The flight duration was 10 days 19 hours 20 minutes 53 seconds. The APUs were shut down 17 minutes 35.4 seconds after landing.

PAYLOADS AND EXPERIMENTS

The payload and experiment operations were very successful during the STS-86 mission. A total of 8,723 lb. of experiment and vehicle equipment, which consisted of 303 transfer items, were delivered to the Mir. In addition, a total of 1717 lb of potable water [17 contingency water containers (CWCs)] were transferred from the Orbiter. A highly successful 5 hour and 1 minute extravehicular activity (EVA), which is discussed later in this report, was also completed.

SPACEHAB SCIENCE

Much of the Spacehab science consisted of experiments that were transferred to or from the Mir Space Station.

Biochemistry of Three Dimensional Tissue (Biotechnology Refrigerator)

The Biochemistry of Three Dimensional Tissue (BIO3D) Biotechnology Refrigerator (BTR) hardware was activated during the prelaunch operations. Throughout the flight, the BTR temperatures ran as much as 4 °C warmer than nominal. As a result, early in the flight, the samples within it were transferred to the thermal electric holding module (TEHM).

The samples were returned to the BTR prior to its transfer to the Mir. Several BIO3D experiment operations were performed on the Orbiter prior to transfer because of real-time power problems on the Mir. These activities were performed safely, although the amount of time required was longer than anticipated. Prior to transfer to the Mir, the unit was inspected for leaks and condensation. The BIO3D hardware transfer to the Mir was completed on flight day 8 at 275:16:28 G.m.t. (06:13:54 MET), and the unit was repowered on the Mir nine minutes later.

Advanced Commercial Generic Bioprocessing Apparatus

The Advanced Commercial Generic Bioprocessing Apparatus (ADV CGBA) status checks while still on the Orbiter revealed nominal operation. The ADV CGBA was transferred to the Mir on flight day 6 and repowered. Status checks after the repowering of the ADV CGBA in the Mir revealed nominal operation.

MIDDECK SCIENCE

Cosmic Radiation Effects and Activation Monitor

The Cosmic Radiation Effects and Activation Monitor (CREAM) transfer to the Mir was initiated at 271:14:14 G.m.t (02:11:40 MET) and the active monitor was activated about one hour later. The transfer of the passive components was completed at 271:16:04 G.m.t. (02:13:30 MET). The active and passive components were deployed in the Mir module, the Kvant-II module and the Kristall module. The active monitor was mounted in several locations within the Mir during the docked phase to obtain equal amounts of radiation data in the minimum and maximum shielding areas. The active monitor was deactivated for entry and returned to the Orbiter after 96 hours of flawless operation inside the Mir. The five passive detector packages and one neutron spectrometer remained in the Mir and will be retrieved during the STS-89 mission.

Biotechnology Specimen Temperature Controller-Mir

The Biotechnology Specimen Temperature Controller-Mir (BSTC-M) was activated during prelaunch operations. Throughout the flight, two of the chamber temperatures ran up to 3 degrees warmer than the set temperature, but the experimenter reported that this condition was acceptable. However, the tissue culture modules were rearranged to place the most sensitive tissues in those chambers that had the best control. Electronic still camera (ESC) photographs of the BSTC-M data screens were downlinked to help characterize and troubleshoot the warmer temperatures. After the rearrangement, the BSTC-M began operating nominally, and the BSTC-M was transferred to the Mir.

MIDDECK PAYLOADS

KidSat

The KidSat mission was very successful with a total of 670 photographs downlinked during the mission. The crew set the camera up earlier than expected and the first pictures were taken during the daylight portion of orbit 4. Two minor problems were encountered during the mission. The first problem occurred during the setup when the KidSat-dedicated payload and ground support computer (PGSC) did not function properly. The crew used backup procedures and configured the camera to be commanded by the Orbiter communications adapter (OCA) PGSC. The second problem involved an intermittent connection in the prime connector cable and a backup cable was used. Both problems were minor and did not significantly affect KidSat operations during the mission. A total of 287 photographs were obtained during the 28.5-hour pre-docking portion of the mission. The post-docking portion of the KidSat mission began on orbit 124, and during the 24-hours of operation 384 photographs were taken. A total of 52 middle schools participated in the STS-86 mission and generated 1138 requests that were satisfied with the 671 photographs that were downlinked.

Cell Culture Module-A

The Cell Culture Module-A (CCM-A) was successfully activated as scheduled. The daily status checks confirmed that the four rail temperatures remained in the range of 36.0 to 37.1 °C, which was well within the nominal range of 35 to 39 °C. The CCM-A was deactivated as planned prior to entry. The principal investigator will report the results of this experiment in separate documentation.

Commercial Protein Crystal Growth

The commercial protein crystal growth (CPCG) experiment was activated approximately four hours into the flight and performed nominally throughout the flight as confirmed by daily status checks.

Seeds In Space-II

The Seeds in Space-II (SEEDS-II) was installed in the Orbiter Processing Facility prior to flight and required no on-orbit operations or activities. The results of this experiment will be reported in separate documentation.

Canadian Protein Experiment

The Canadian Protein Experiment (CAPE) was transferred to the Mir during flight day 5. The power losses in the Priroda module of the Mir Space Station did not affect the CAPE.

Shuttle Ionospheric Modification with Pulsed Local Exhaust

The Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) was manifested on STS-86 as a payload of opportunity. The flight control team scheduled a SIMPLEX pass over Jicamarca, Peru, on flight day 8 at 277:20:32:14.2 G.m.t. (08:17:57:55 MET). The OMS maneuver was 10.2 seconds in duration and resulted in an differential velocity (ΔV) of 8.3 ft/sec. The SIMPLEX customer reported that good radar data were obtained from the Jicamarca, Peru, Ionospheric Observatory. The results of this experiment will be reported in separate documentation.

RISK MITIGATION EXPERIMENTS

RME 1303-1 - Shuttle/Mir Experiment Kit Transport, Enhanced Dynamic Load Sensor

Data were obtained for this experiment, and the crew transferred the Shuttle/Mir Experiment Kit Transport, Enhanced Dynamic Load (EDL) data disks to the Orbiter at 272:23:39 G.m.t. (03:21:05 MET). The results of the risk mitigation experiment (RME) will be reported in separate documentation.

RME 1303-2 - Shuttle/Mir Experiment Kit Transport, Mir Auxiliary Sensor Unit for Mir Structural Dynamics Experiment

The crew transferred the Mir Structural Dynamics Experiment (MiSDE) data disks to the Priroda module, which is part of the Mir Space Station, at 272:23:39 G.m.t. (03:21:05 MET). One of the disks was used to record MiSDE data during the EVA, and this disk was returned and given to the experimenter. Also, all of the data disks left during a previous flight were also returned. The results of this RME will be reported in separate documentation.

RME 1303-5 - Space Portable SpectroReflectometer

The crew reported that the Space Portable SpectroReflectometer (SPSR) and associated equipment was transferred to the Priroda module at 272:01:43 G.m.t. (02:23:09 MET). Data will be collected during the Mir mission and returned to Earth on an upcoming flight. The results of the future data evaluation will be reported in separate documentation.

RME 1304 - Mir Environmental Effects Payload

A 5-hour and 1-minute EVA was performed to retrieve the four Mir Environmental Effects Payload experiment packages from the Mir Space Station. All four packages were transferred to the payload bay where the packages were attached for entry. A minor fit problem was encountered with carrier 2, but it was resolved satisfactorily. The results of this experiment will be published in separate documentation.

RME 1314 - ESA Proximity Operations Sensor

The European Space Agency (ESA) Proximity Operations Sensor (EPS) operations were very successful. The unit was turned on early, as planned, to prevent the sensor from becoming over-cooled. Tracking was good during the approach to the Mir. Although the Mir was shading the antennas and the attitudes of the Mir and the Orbiter were not favorable, the receiver maintained its position fix throughout the rendezvous sequence.

The EPS hardware was turned on during the docked configuration to evaluate multipathing and shadowing effects on the Global Positioning System (GPS) receiver initialization and performance. The GPS 1 receiver was successfully initialized several times and position fixes were achieved. Initial data indicate that the receiver needs more time to achieve a position fix when docked with the Mir. However, once a position fix was achieved, the receiver performance was not strongly impacted by the Mir attitudes.

The EPS 2 receiver was powered for several hours without acquiring a satellite or a position fix. Subsequently, the processor was deactivated to reset the processor. After testing, a large oscillator offset was found to be the cause of the problem. The proper oscillator offset was uplinked and receiver 2 acquired the NAVSTAR satellite and achieved a position fix after 10 minutes. Tests were performed to verify cold-start performance, and a position fix was achieved after one hour. The optical head and electronic boxes were powered to maintain an acceptable thermal environment. Post-undocking data collections were also successful. The detailed results of this RME will be reported in separate documentation.

RME 1317 - Mir Structural Dynamics Experiment Joint Operations

The Mir Structural Dynamics Experiment (MiSDE) activations and deactivations were conducted satisfactorily and in accordance with the flight plan. The treadmill, vernier RCS thruster firings, and Mir thruster-firing sequences and times were adjusted to allow for the Mir firings over Russian ground stations. The initial data analysis showed a possibility that the major modal frequency of the mated stack may have shifted. Detailed analyses have been continuing since the end of the mission. MiSDE was activated during the EVA to record the effect of extravehicular and intravehicular activities (IVAs).

RME 1320 - Radiation Monitoring Equipment-III

The Radiation Monitoring Equipment-III (RME-III) transfer to the Mir Space Station began at 271:18:35 G.m.t. (02:16:01 MET) with activation and setup completed 34 minutes later. The G.m.t. and MET timers on the unit were updated to the correct values. Memory module change-out occurred at 272:22:19 G.m.t. (03:19:45 MET). The crew reported later that main module 1 contained the serial number (S/N) 3 memory module, and main module 2 contained S/N 1 memory module. The second memory module change-out was completed at 273:14:50 G.m.t. (04:11:56 MET). A system battery-low indication was noted on main module 1 before memory module change-out; however, after the module change-out the system operated normally. Main module 1 had memory module S/N 11 and main module 2 had memory module S/N 5 installed. The third memory module change-out was completed at approximately 274:14:03 G.m.t. (05:11:29 MET). The fourth and final memory change-out was completed at

281:02:04 G.m.t. The hardware was stowed for entry with the two main modules remaining powered.

RME 1332 - Space Station - Test of PCS Hardware

The crew reported that the laptop computer (FA-2) used for the test of PCS (TPCS) hardware had an error on the initial buildup that was corrected by a reboot of the computer. The error is being investigated, but no firm conclusions have been reached. After 70 hours and 15 minutes of operation, unit 1 logged a total of six single event upsets (SEUs), and unit 2 had logged eight SEUs.

VEHICLE PERFORMANCE

The flight evaluation results for the SRB, RSRM, ET, SSME, SRSS and Orbiter subsystems are discussed in this section of the report.

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed as expected. The SRB prelaunch countdown was normal, and no SRB Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specification Document (OMRSD) violations occurred. No in-flight anomalies were identified from the review and analysis of the flight data.

First stage ascent performance was as expected. Both SRBs were successfully separated from the External Tank (ET) approximately 123.003 seconds after liftoff. SRB entry, deceleration and water impact occurred as anticipated. Reports from the recovery area indicated that all deceleration subsystems performed as designed. Because of the night launch, the SRBs were not observed during descent except by radar. The SRBs were recovered the following morning and returned to Kennedy Space Center (KSC) for inspection, disassembly, and refurbishment. At the time that this report was completed, the inspection and disassembly were completed and the refurbishment activities were underway.

REUSABLE SOLID ROCKET MOTORS

The Reusable Solid Rocket Motor (RSRM) performance parameters were within Contractor End Item (CEI) specification limits. The RSRM countdown was nominal, and no RSRM LCC or OMRSD violations occurred. The calculated propellant mean bulk temperature (PMBT) was 82 °F at the time of launch. The maximum trace shape variation of pressure versus time during the 62-80-second time frame was calculated as -0.46 percent at 75 seconds for the left motor, and -0.63 percent at the 73-second time frame for the right motor. These values were well within the 3.2 percent requirement. No in-flight anomalies were identified from the review and analysis of the data. The propulsion performance for the RSRMs are shown in the table on the following page.

Power-up and operation of all igniter and field joint heaters was accomplished as planned. Power was applied to the field joint heaters 16 percent of the time, maintaining the field joints within the normal operating range. The power was applied to the igniter joint heaters approximately 27 percent of the time, and the igniter joints were maintained within the normal operating temperature range. All RSRM temperatures were maintained within acceptable limits throughout the countdown. For this flight, the heated ground purge in the aft SRB skirts that is used to maintain the case/nozzle joint temperatures within the required LCC ranges was not powered until T-15 minutes at which time it was turned on in the high-flow-rate mode to inert the aft skirt compartment. During the LCC time frame, the nozzle/case joint sensor temperatures ranged from 80 to 85 °F on both motors. The calculated flex bearing mean bulk temperature (FBMBT) was 81 °F.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 82 °F		Right motor, 82 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10 ⁶ lbf-sec	66.28	66.30	66.62	66.33
I-60, 10 ⁶ lbf-sec	176.37	176.48	177.13	176.70
I-AT, 10 ⁶ lbf-sec	296.63	297.09	296.70	297.29
Vacuum Isp, lbf-sec/lbm	268.6	269.1	268.6	269.2
Burn rate, in/sec @ 60 °F at 625 psia	0.3682	0.3677	0.3693	0.3679
Event times, seconds ^a				
Ignition interval	0.232	N/A	0.232	N/A
Web time ^b	108.6	108.6	108.1	108.4
50 psia cue time	118.3	117.9	117.7	117.8
Action time ^b	120.3	120.1	119.8	120.2
Separation command	123.2	123.0	123.2	123.0
PMBT, °F	82	82	82	82
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	3.0	2.8	3.1
Tailoff Imbalance Impulse differential, Klbf-sec	Predicted		Actual	
	N/A		717.3	

Impulse Imbalance = Integral of the absolute value of the left motor thrust minus right motor thrust from web time to action time.

^aAll times are referenced to ignition command time except where noted by a ^b

^bReferenced to liftoff time (ignition interval).

EXTERNAL TANK

All objectives and requirements associated with the External Tank (ET) loading and flight operations were satisfactorily met. The start of liquid hydrogen (LH₂) loading was delayed approximately 1 hour 30 minutes because of a LH₂ loading console software problem. The launch of the vehicle was not delayed because of the loading delay. All ET electrical equipment and instrumentation operated satisfactorily. The ET purge and heater operations were monitored and all performed properly. No ET LCC or OMRSD violations occurred, nor were any in-flight anomalies identified from the review and analysis of the data.

No unexpected ice/frost formations were observed on the ET during the countdown. There was no observed ice or frost on the acreage areas of the ET. Normal quantities of ice or frost were present on the LO₂ and LH₂ feed-lines, the pressurization line brackets, and along the LH₂ protuberance air load (PAL) ramps. All ice/frost observations were acceptable per NSTS 08303. The ice/frost personnel reported that there were no anomalous TPS conditions; however, the recurring crack in the thermal protection system (TPS) where the foam bridges between the vertical strut cable tray and fitting fairing was present but only one-inch in length.

STS-86 was the first flight with the composite nose cone. Once the gaseous oxygen (GO₂) vent hood was removed, ice formation was observed in the area around the

louvers that had not been observed on previous metal-substrate nose cones. The Ice/Frost Red Team deemed the condition acceptable.

The ET pressurization system functioned properly throughout engine start and flight. The minimum LO₂ ullage pressure experienced during the ullage-pressure slump was 14.08 psid.

ET separation occurred as planned with no anomalies. Main engine cutoff occurred within expected tolerances and ET entry and breakup were nominal. The postflight predicted ET intact impact point was within the footprint and approximately 88 nmi. uprange of the preflight predicted impact point.

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle main engine (SSME) parameters were normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights. Engine ready was achieved at the proper time; all LCC were met; and engine start and thrust build-up were normal. All ignition confirm limits and mainstage redline margins were satisfactory. All interface control document (ICD) start and shutdown transient requirements were met. Engine performance in all areas was as predicted. Cutoff off times for SSME 1, 2, and 3 were 517.21, 517.33, and 517.44 seconds, respectively. The I_{sp} was rated at 452.58 seconds, based on trajectory data. Controller and software performance was satisfactory with no problems identified.

Flight data indicate that SSME performance during main-stage, throttling, shutdown and propellant-dump operations was normal and revealed no in-flight anomalies. The high pressure oxidizer turbopump (HPOTP) and the high pressure fuel turbopump (HPFTP) temperatures were well within specification. The Space Shuttle main engine cutoff (MECO) occurred 510.866 seconds after liftoff.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the launch countdown. All SRSS safe and arm (S&A) devices were armed and system inhibits turned off at appropriate times. All SRSS measurements indicated that the system operated as expected throughout the countdown.

As planned, the SRB S&A devices were safed, and SRB system power was turned off prior to SRB separation. The ET system was deleted from this and a number of previous vehicles.

Analysis of the flight data indicated nominal performance of the SRSS except that the right SRB signal strength B exceeded the range-safety minimum requirement of -85 dBm when tracking with the Cape command site. The lowest observed right SRB signal strength B was -90.3 dBm (1.12 Vdc) at liftoff plus 111.04 seconds, and this condition did not affect system operation. Data indicate that the combined signal strength of all four SRB SRSS integrated receiver decoders (IRDs) were always sufficiently strong to maintain satisfactory system operation up to SRB separation. The observed low signal strength B is an expected condition that occurs on high inclination flights and is caused by plume attenuation and right SRB shading. The STS-86 mission had a high inclination of 51.6 degrees.

ORBITER SUBSYSTEMS PERFORMANCE

Main Propulsion System

The overall prelaunch and in-flight performance of the main propulsion system (MPS) was nominal. The LO₂ and LH₂ loadings were performed with no stop-flows or reverts. Also, there were no LCC or OMRSD violations.

No significant hazardous gas concentrations were detected during the preflight operations period. The maximum hydrogen concentration level in the Orbiter aft compartment, occurring just after the start of fast-fill, was approximately 197 ppm. This level compares favorably with previous data for this vehicle.

Loading was delayed for approximately 1.5 hours because of a problem with the LH₂ loading console software. LH₂ loading operations were normal through chill-down, fast-fill, topping and replenish. Based on an analysis of the loading system data, the LH₂ load at the end of replenish was 231,407 lbm, which when compared with the inventory (predicted) load yielded a small difference that was well within the required MPS loading accuracy of ± 0.37 percent.

The LO₂ loading operations were normal through chill-down, slow fill, fast fill, topping and replenish. Based on an analysis of the loading system data, the LO₂ load at the end of replenish was 1,388,660 lbm. Comparison of the actual load with the planned load showed a difference of 68 lbm, which is well within the required loading accuracy of ± 0.43 percent.

Ascent MPS performance was nominal. Data indicate that the LO₂ and LH₂ pressurization and feed systems performed nominally and satisfied all tank ullage pressure and SSME inlet net positive suction pressure (NPSP) requirements. The minimum LO₂ ullage pressure experienced during the period of the ullage pressure slump was 14.08 psid.

The MPS LO₂ engine cutoff (ECO) sensors flashed dry 2.3 seconds after SSME cutoff. The flash was caused by the helium injected into the LO₂ system at MECO and was aggravated by the low performance margin for this flight. This sensor indication occurs on approximately 60 percent of the flights. MECO residuals were estimated to be 5800 lbm versus the predicted value of 5879 lbm. The propellant dump operations following MECO were nominal as were the vacuum inerting operations.

During the MPS 650-second gaseous helium (Ghe) purge during entry at 279:21:53:30 G.m.t. (010:19:19:11 MET), the MPS engine 2A and 2B regulators and the pneumatic regulator (each are 750-psia regulators) exhibited an outlet pressure shift of approximately 20 psi. The outlet pressure recovered in approximately 10 seconds and then spiked again. This shift repeated eight times over approximately 1.5 minutes and then recovered and operated nominally until completion of the blow-down purge. The regulator outlet pressure never exceeded the File IX requirements and the total helium usage during the purge was nominal. The fact that the three regulators are close-coupled and the performance of one regulator is highly influenced by the other regulator's performance prevented an early determination of which regulator might have caused the oscillation. Postflight ground tests could not reproduce the condition; however, a review of data from previous flights showed similar oscillations at the same

altitude during entry. It is now believed that the spikes are caused by the operation of the 20-psia manifold repressurization regulators as they allow "bursts" of Ghe to the manifolds. This condition in turn causes the observed spikes on the 750-psia side. Analysis is continuing to determine if the operation of the 20-psia regulator is detrimental in any way to the regulators.

Reaction Control Subsystem

The reaction control subsystem (RCS) performed nominally throughout the mission. One RCS thruster (L3D) failed off during the ET separation sequence, and the anomaly is discussed in the following paragraph. A total of 6643 lbm of propellants were consumed by the RCS during the mission. Of this total, 2449.2 lbm of propellants were provided by the orbital maneuvering subsystem during left- and right-pod interconnect operations. The primary RCS had a total of 6429 firings, and a total firing time of 1069.76 seconds. The vernier RCS had a total of 22,175 firings, and a total firing time of 31,152.44 seconds.

The following table lists the RCS maneuvers performed during the rendezvous with the Mir Space Station. The OMS maneuvers performed during the rendezvous are shown in the following section of the report.

Maneuver	Time, G.m.t./MET	ΔV , ft/sec	Duration, seconds
NC3/RCS	270:03:22:20 G.m.t. 01:00:48:01 MET	4.4	18
NPC	Not done	-	-
NCC/RCS	270:16:34:13 G.m.t. 01:13:59:54 MET	1.6	7
TI/RCS	270:17:31:55 G.m.t. 01:15:57:36 MET	5.6	23
MC1/RCS	270:17:41:13 G.m.t. 01:15:06:54 MET	0.2	1
MC2/RCS	270:18:25:13 G.m.t. 01:15:50:54 MET	1.3	5
MC3/RCS	270:18:42:13 G.m.t. 01:16:07:54 MET	1.2	5
MC4/RCS	270:18:52:13 G.m.t. 01:16:17:54 MET	1.2	5

Primary RCS thruster L3D failed off during its first commanded firing following ET separation (Flight Problem STS-86-V-02), and the thruster was not used for the remainder of the mission. During the firing, the chamber pressure (P_c) did not rise above 4 psia, and the thruster was deselected due to a low P_c indication. The L3D injector temperature data profile was indicative of a normal firing suggesting that the thruster did fire. Data review showed that the L3D P_c slowly decreased from approximately 18 psia to 4 psia over a 7-minute period during ascent, whereas the decay time should have occurred in approximately 1.5 minutes. The P_c remained at the 4 psia level throughout the mission, which along with the 18 psia prelaunch indication, indicates that a bias existed in the measurement. Note that a bias in the P_c measurement is not unusual, and the LCC requirement for the measurement is the ambient temperature ± 10 psia. Following landing, the P_c remained at 4 psia for over an hour before slowly rising to approximately 15 psia over an 18-minute period. The data from ascent and the ET separation firing indicate that the cause of the condition is

probably a plugged P_c tube and is unrelated to the bias in the measurement. Since the OV-104 vehicle is going to OMDP, the left OMS pod (LP03) has been removed and sent to the HMF for its OMDP. All thrusters are scheduled to be removed and sent to White Sands Test Facility (WTSF) for normal OMDP processing. Therefore, the investigation of the L3D failure will be performed at the WSTF.

During the RCS firings for ET separation, primary RCS thruster R1U data indicate that the thruster R1U oxidizer valve bounced due to firings of thrusters R4D, R3D and R2D. Evidence of valve bounce could be seen in the oxidizer injector temperature and the chamber pressure data. The RCS was configured for straight feed at the time. Additionally, during the Mir rendezvous, thruster R1U data indicate that the fuel valve bounced with every simultaneous firing of thrusters R2D and R4D (-Z translations). Evidence of valve bounce could be seen in the fuel injector temperature data. The RCS was configured for left OMS interconnect during the rendezvous. A single thruster R1U fuel valve bounce occurred during Mir undocking operations. It occurred with the RCS in straight feed during a simultaneous firing of thrusters R4R, R2D, and R4D. Thruster valve bounce has been experienced in the past. The oxidizer valve bounces, although appearing larger than normal, are not unusual during ET separation. The number of fuel valve bounces, seen with every -Z translation, were unusual.

Thruster R1U performed nominally during the RCS hot-fire. To test a theory that the fuel valve bounces were caused by gas in the fuel valve/feed line, three -Z translations were performed while in left OMS interconnect prior to and after the RCS hot-fire. Valve bounces were not observed. It is believed that the valve bounces were caused by gas in the system that cleared. Since OV-104 is going to OMDP, the OMS pod RP04 will be sent to the Hypergolic Maintenance Facility (HMF) for its OMDP. All thrusters will be removed and sent to the White Sands Test Facility (WSTF). Thruster R1U will be flushed and will undergo normal acceptance testing.

The RCS hot-fire was performed immediately following FCS checkout. All primary thrusters fired nominally during the hot-fire, except L3D which was not fired because of the fail-off condition that was discussed earlier in this section.

Orbital Maneuvering Subsystem

The orbital maneuvering subsystem (OMS) performed satisfactorily throughout the mission. No LCC or OMRSD deviations occurred prior to launch, and no in-flight anomalies occurred during the mission. A total of 19,836.7 lbm of OMS propellants were consumed during the mission, and of this total 2449.2 lbm were consumed by the RCS during interconnect operations.

The direct insertion ascent trajectory resulted in the OMS 1 maneuver not being required. The table on the following page provides pertinent data about the seven OMS maneuvers that were performed during the mission.

The OMS 2 maneuver was performed satisfactorily and the resultant orbit was 161 by 139 nmi. During the maneuver, the left OMS fuel total quantity indication dropped to 45-percent immediately after the 14-second gage-lockout period. Data indicate that the forward probe quantity signal was lost. During the OMS 5 maneuver after the 14-second totalizer settling burn integrator was completed, the gaging measurement began operating properly. Similar behavior has been noted on the previous four missions of this OMS pod (LP03) and was expected.

The second OMS maneuver (OMS 3) was a dual engine, straight-feed firing, and the resultant orbit was 200.9 by 150.8 nmi. Data indicated nominal OMS performance.

OMS MANEUVERS

Maneuver/Engines	Time, G.m.t./MET	ΔV , ft/sec	Duration, seconds
OMS 2/ 2	269:03:16:09 G.m.t. 00:00:41:50 MET	171.6	108.7
NC1/OMS 3/ 2	269:05:59:09 G.m.t. 00:03:24:50 MET	94.4	59.12
NC2/OMS 4/ 2	269:17:26:15 G.m.t. 00:14:51:56 MET	57.5	36.8
NC4/OMS 5/ 2	270:15:59:25 G.m.t. 01:13:25:06 MET	42.7	26.3
OMS 6/ 2	276:22:25:27 G.m.t. 07:19:51:08 MET	33	19
OMS 7/ 1 (left)	277:20:32:13 G.m.t. 08:17:57:55 MET	8	10
Deorbit/ 2	279:20:47:45 G.m.t. 10:18:13:26 MET	344	195

At 269:17:26 G.m.t. (00:14:51 MET), the OMS 4 (NC2) dual-engine, straight-feed maneuver was initiated, and the resultant orbit was 209 by 176 nmi. Data from this maneuver showed nominal performance from both engines. Likewise, OMS performance during the OMS 5 dual-engine maneuver was satisfactory.

The OMS 6 two-engine straight-feed firing was initiated at 276:22:25:27.2 G.m.t. (07:19:51:08.2 MET) and was also completed satisfactorily with good subsystem performance.

The OMS 7 maneuver was performed in support of Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) at 277:20:32:14.2 G.m.t. (08:17:57:55.2 MET) using the left orbital maneuvering engine in straight-feed. Subsystem performance was nominal during the maneuver.

The dual-engine deorbit maneuver for the first landing opportunity on the first contingency landing day was performed on orbit 169 at 279:20:47:45.3 G.m.t. (010:18:13:26.3 MET).

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performance was nominal throughout the mission. The subsystem provided the fuel cells with 2706 lbm of oxygen and 341 lbm of hydrogen for the production of electricity. In addition, the environmental control and life support system (ECLSS) was supplied 211 lbm of oxygen which included approximately 75.7 lbm that was supplied to the Mir. A mission extension capability of nearly three days was possible at average power levels based on the cryogenics remaining at landing.

Fuel Cell Powerplant Subsystem

Performance of the fuel cell powerplant subsystem was nominal throughout the mission with one in-flight anomaly identified from the data. The average electrical power level

and load for the mission was 15.2 kW and 495 amperes. The fuel cells produced 3950 kWh of electrical energy and 3047 lbm of by-product potable water. Five purges of the fuel cells using both the automatic and manual systems were performed satisfactorily during the mission.

The fuel cell 2 substack cell performance monitor (CPM) differential voltage output exhibited an unusual increase to the 300 to 500 mV range (500 mV for 2 seconds) for about 15 seconds starting at 269:02:35:21 G.m.t. (00:00:01:02 MET) (Flight Problem STS-86-V-01). The CPM reading then decreased to the 100 to 200 mV range for about 20 seconds. After 61 seconds, the output returned to the normal range of 6 to 8 mV, and no anomalous indications were noted from the fuel cells. Because of this ascent event, main busses A and B were bus tied at 269:02:46 G.m.t. (00:00:11 MET), and as a precaution, the bus tie remained until deorbit preparations. The CPM performed nominally for the remainder of the mission and the fuel cell 2 substack 1 differential voltage remained in the 2 to 8 mV range. The data indicate that this event was most probably caused by an instrumentation problem, and the event was not the result of a physical or chemical problem within the substack. Postflight troubleshooting of the Orbiter instrumentation system did not reproduce the anomaly. The fuel cell was removed from OV-104 (as planned) and was sent to the vendor for failure investigation.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performed satisfactorily throughout the mission. No in-flight anomalies or significant problems were noted during the course of the mission. The APU run times and fuel consumption are shown in the following table.

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (S/N 407)		APU 2 (S/N 402)		APU 3 (S/N 308)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	19:45	47	20:04	51	20:16	52
FCS checkout	06:24	16				
Entry ^a	61:53	109	89:38	168	62:05	132
Total	88:02	172	109:42	219	82:21	184

^a APUs were shut down 16 minutes 26 seconds after landing.

^b APU 1 was used for the FCS checkout.

Auxiliary power unit (APU) performance was nominal during ascent with the exception of a noisy output from the APU 2 exhaust gas temperature (EGT) 1 sensor. This is a repeat of a problem that occurred during STS-84, and the transducer will be replaced during the upcoming OV-104 OMDP.

Following the APU heater reconfiguration, the APU 2 gas generator (GG) bed system B heater cycled at a higher-than-expected rate (Flight Problem STS-86-V-03); however the proper GG bed temperature was maintained. As a result of the heater performance, the injector temperature remained nearly constant at 359 °F after the heater reconfiguration. Similar performance has been seen on this heater during previous

flights of this APU (S/N 402), but the frequency had increased since the condition was first noted on STS-50 (seven flights). It is believed to be caused by the GG bed temperature sensor, which is used by the APU controller to control the B heater, being very close to the heater. This location results in frequent heater cycling and a dithering appearance in the injector temperature. Special testing of the APU will be performed after the unit is removed from the vehicle.

The flight control subsystem (FCS) checkout was performed using APU 1. APU 1 performed nominally during the checkout. APU 1 was started at 277:15:49:40.072 G.m.t. (08:13:15:40.072 MET) and ran for 6 minutes 24 seconds with a fuel consumption of 16 lb. Although no gearbox repressurizations occurred during the run (gearbox pressure was at 8 psia), two did occur during entry. This was a known condition for this APU (S/N 407) as it has repressed on eight of the last 10 flights.

At 277:23:50 G.m.t. (08:21:16 MET), the B-string thermostat controlling the APU 3 fuel-line heaters began to show the characteristic signs of a dithering thermostat. The APU 3 fuel feed-line heaters can be controlled by either of two thermostats wired in parallel. Each thermostat has a monitoring temperature measurement (V46T0308A for thermostat S39B and V46T0304A for thermostat S34B). Before the dithering began, it appeared that the S34B thermostat was in control, and it is suspected to be the dithering thermostat. These thermostats are in a low vibration environment and no postflight action is required.

Hydraulics/Water Spray Boiler Subsystem

The overall hydraulics and WSB subsystem performance was nominal, and one in-flight anomaly was identified.

At 269:02:34:58 G.m.t. (39 seconds MET), the WSB 3 quantity indication dropped to 0 percent for 1 second resulting in a WSB 3 quantity alarm being generated. This event corresponded to a dropout of the WSB 3 GN₂ regulator outlet pressure from about 40.1 psia to 0 psia and back to 38.7 psia within a 2-second period. The transducer exhibited the same condition during entry. This transducer behavior has been noted on previous flights, and the transducer is scheduled to be replaced during the upcoming OV-104 OMDP with a newly designed transducer.

No water spray boiler (WSB) cooling occurred during the FCS checkout because of the short APU run time.

At 278:21:59 G.m.t. (09:19:25 MET), during the time period between the first and second landing opportunities, the WSB 3 vent temperature decreased to off-scale-low (122 °F) (Flight Problem STS-86-V-06). Nominally, the heater should have cycled on at approximately 145 °F. The system had been operating on the B controller for over 3 hours when the data indicated that the B heater had failed off. At 278:22:28 G.m.t. (09:19:54 MET), WSB 3 was switched to the A controller and a rise in the vent temperature was observed a short time later. Following the second landing wave-off at 278:23:32 G.m.t. (09:20:58 MET), the B controller was reselected. The WSB 3 vent temperature did not recover above 122 °F. This same problem was seen during deorbit preparations on STS-76 (OV-104) and it subsequently recovered during that mission. STS-76 postflight troubleshooting did not isolate the problem, and the problem did not recur during STS-79, STS-81, or STS-84.

Two over-cooling incidents were observed during entry on WSB system 1. The first occurrence was noted immediately following the initiation of spray cooling. The lubrication oil temperature dropped from 251 °F to 227 °F before returning to a steady-state temperature of 251 °F. The second over-cooling condition occurred approximately 15 minutes later when the lubrication oil temperature dropped from 249 °F to 199 °F and then rebounded to 253 °F. Neither of these occurrences impacted the entry and landing operations.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performed nominally throughout the mission. No abnormal conditions or in-flight anomalies were identified from the review of the data.

An 80-ampere spike of 0.3-second duration occurred at 269:07:40 G.m.t. (00:05:05 MET). Data indicate that the load was on main bus B. The crew reported that circuit breaker CB4 on the MUP was open. CB4 supplied power to the two PGSCs for the GPS/INS DTOs 700-12 and 700-15. A more detailed discussion of this condition is contained in the Development Test Objective section of this report.

Orbiter Docking System

The ODS performed nominally throughout the three phases of docking which were:

- a. Docking ring extension;
- b. Docking with the Mir Space Station; and
- c. Undocking from the Mir Space Station.

The ODS was powered up for the docking ring extension at 270:00:38:34 G.m.t. (00:22:04:15 MET). The docking ring was extended from the final position to the initial position at 270:00:40:05 G.m.t. (00:22:05:46 MET) in preparation for the docking. The ODS performed nominally within dual motor times throughout the docking-ring extension procedure.

The ODS avionics hardware performed nominally throughout the docking sequence with the one exception, which is noted in the following paragraph. Capture occurred nominally at 270:19:57:46 G.m.t. (01:17:22:46 MET). The structural hooks were closed and docking was completed at 270:20:06:15 G.m.t. (01:17:31:56 MET). The loads and mechanism performance during the docking sequence were nominal.

The ODS heater no. 2/DCU power-indication toggling-off problem that was seen on previous missions (STS-76, STS-81 and STS-84) recurred during the docking with and undocking from the Mir. The signal was present when the ODS was initially powered up and toggled off at approximately 270:20:06:06 G.m.t. (01:17:31:56 MET). The signal remained off through ODS power down. The problem recurred when the ODS was used for the undocking. Again the signal was present during ODS power up, then toggled off at 276:17:18:00 G.m.t. (07:14:43:41 MET) and remained off through ODS power down. This condition is only an indication loss and the decision had been made to fly as-is. The DCU will be removed as part of modifications during the upcoming OV-104 OMDP, and no further troubleshooting of this ODS is planned.

Pressure Control Subsystem

The pressure control subsystem (PCS) performed satisfactorily throughout the mission, and one in-flight anomaly was identified.

To save as much nitrogen as possible for transfer to the Mir, normal cabin leakage make-up was not implemented prior to docking, and the cabin was not depressurized to 10.2 psia for the EVA operational period. The Orbiter pressure was down to 14.3 psia during docking to Mir and was down to 12.6 psia when the Shuttle/Mir pressure was equalized. The ODS-to-tunnel adapter hatch and hatch A were closed in preparation for EVA. The pre-EVA cabin pressure was 12.6 psia, and the cabin was pressurized to 14.07 psia during the EVA.

A repressurization of the Orbiter/Mir vehicle was started at 275:01:52 G.m.t. (05:23:18 MET) using PCS 1 to provide the N₂, PCS 2 to provide the O₂ and the direct O₂ valve open. The N₂ flow rate decreased to low flow 43 minutes later at a cabin pressure of 14.3 psia (Flight Problem STS-86-V-05) as the regulator transitioned from high to low flow. The repressurization was terminated by the crew at 275:02:40 G.m.t. (06:00:06 MET). The crew reported that ice had formed on the PCS panel. Typically, the regulator would not have transitioned from high to low flow until the pressure had reached 14.5 to 14.6 psia.

Repressurization of the Orbiter/Mir vehicle from 14.3 to 14.62 psia using PCS 2 was initiated at 275:13:02 G.m.t. (06:10:28 MET) and was completed at 275:13:34 G.m.t. (06:11:00 MET). Cabin pressure was then raised from 14.62 to 14.7 psia using PCS 1 beginning at 275:13:34 G.m.t. (06:10:59 MET) and finishing at 275:14:25 G.m.t. (06:11:50 MET). Both PCS regulators performed nominally. After the N₂ pressurization was complete, O₂ repressurization was begun using the repressurization restrictor. The O₂ repressurization was terminated at 275:22:04 G.m.t. (06:19:30 MET) at a cabin pressure of 15.10 psia. Initial indications are that the long duration high-flow rate (approximately 187 lb/hr) of N₂ flow through the cabin regulator chilled the regulator enough to cause the early transition from high flow to low flow.

The total vehicle pressure before undocking was 15.1 psia and the PPO₂ was 3.90 psia. The total consumables transferred to the Mir were 130.1 lb of N₂ and 75.7 lb of O₂. In addition eight LiOH canisters were also transferred.

Atmospheric Revitalization System

The atmospheric revitalization subsystem (ARS) performed satisfactorily throughout the flight with no in-flight anomalies or significant problems identified. All monitored parameters remained within nominal limits throughout the flight.

Active Thermal Control Subsystem

The active thermal control subsystem (ATCS) operation was satisfactory throughout the mission.

Radiator flow was initiated at 269:03:55 G.m.t. (00:01:21 MET) and the payload bay doors were fully opened 12 minutes later. The radiators were not deployed during this

flight. At 269:03:56 G.m.t. (00:01:22 MET), the flash evaporator system (FES) primary A was turned off and primary B was turned on. This allowed the FES to use water from supply tanks C and D and save the water in tanks A and B for transfer to the Mir. At the completion of the Mir water transfer, the supply tanks were reconfigured to the nominal on-orbit configuration and the FES was switched back to primary A. After the wave-off of the landing on the planned landing day, the FES was turned off to conserve water for the extension-day landing attempts.

The Freon coolant loop (FCL) 2 flow proportioning valve (FPV) was taken to the payload position to provide cooling for the Spacehab module. At the end of Spacehab module operations on the ninth day of the mission, the FCL was taken back to interchanger flow. Hydraulic circulation pump 2 and the OMS pod B heaters were turned on for the crew sleep period to increase water production.

The radiator cold-soak provided cooling during entry through landing plus 2 minutes when ammonia boiler system (ABS) B was activated. System B provided cooling for 35 minutes at which time the tank B pressure began to blow-down. Two minutes after the system B shutdown, ground cooling was activated.

Supply and Waste Water System

The supply and waste water system performed nominally throughout the mission. All in-flight checkout requirements were completed satisfactorily prior to landing.

Prior to launch, a level of 127 colonies of bacteria (psuedomonas) were measured in the supply water, and the limit is 100 colonies of bacteria. A galley flush of four strokes on the galley needle was performed at approximately T-4 hours, after which the supply water was acceptable for flight.

Supply water was managed through the use of the FES and water transfer to the Mir Space Station. The supply water dump line temperature was maintained between 70 °F and 94 °F throughout the mission with the operation of the line heater.

At 269:02:50 G.m.t. (00:00:16 MET), the water tank B quantity measurement exhibited data dropouts in the 80-percent range. This tank B measurement has exhibited similar behavior during STS-79, STS-81 and STS-84. The sensor will be replaced during the upcoming OV-104 OMDP. There was no mission impact resulting from the performance of this measurement sensor.

Also, the supply water dump line system A heater thermostat dithered at approximately 79 °F. When the dump-line heaters were reconfigured from A to B, the system B heater thermostat cycled nominally.

A total of 17 contingency water containers (CWCs) were filled with a total of 1717 lb of water, which was transferred to the Mir Space Station. CWCs 1, 3, 7, 9, 13, and 15 were filled with potable water, and the rest of the CWCs were filled with technical water. The water was de-iodinated as the CWCs were filled. Silver biocide and minerals were added to the potable water, and only silver biocide was added to the technical water. The water in CWCs 1, 3, 7, 9, 12, 15 and 17 was sampled after the CWCs were full.

Waste water was gathered at the predicted rate. Five waste water dumps were performed at an average dump rate of 1.93 percent/minute (3.19 lb/min) for a total of

512 lb of waste water that was dumped. The waste water dump line temperature was maintained between 56 °F and 75 °F throughout the mission.

Waste Collection System

The waste collection system performed satisfactorily throughout the flight with no problems noted or reported by the crew.

Airlock Support System

The airlock support system performed satisfactorily in support of the 5 hour 1 minute EVA. The active system monitor parameters indicated normal outputs throughout the duration of the flight.

In preparation for the EVA, the airlock depressurization from 12.6 psia to vacuum began at 274:17:15 G.m.t. (05:14:40 MET) using the airlock depressurization valve and was terminated at 274:17:32:29 G.m.t. (05:14:58:10 MET) without any problems. The EVA began when the crew members placed their EMU power switch to the battery position at 274:17:29 G.m.t. (05:14:54 MET). Astronaut Scott Parazynski (EV1) and Cosmonaut Vladimir Titov (EV2) successfully completed the scheduled EVA. The EVA ended with the start of repressurization at 274:22:30:02 G.m.t. (05:19:55:02 MET).

After the EVA, a rapid decrease of cabin pressure was observed during airlock repressurization and the activity was stopped at 5 psia airlock pressure for evaluation. The crew reported that the closure of the airlock depressurization valve was overlooked and was closed immediately prior to the 5-psia hold. Airlock repressurization was resumed, but about 15 lb of air was lost prior to the depressurization valve being closed. At the completion of the airlock repressurization, the cabin/airlock pressure was 11.4 psia, and the pressure was raised to 12.7 psia before equalizing with the ODS, Spacehab and Mir pressure at 12.5 psia.

Smoke Detection and Fire Suppression Subsystem

The smoke detection and fire suppression subsystem showed no indications of smoke generation during the flight. Use of the fire suppression subsystem was not required.

Flight Data Systems

The flight data systems performed satisfactorily during the mission, and no in-flight anomalies occurred during the mission.

Flight Software

The flight software performed nominally throughout the mission with no in-flight anomalies identified from the review of the data.

Flight Control Subsystem

The flight control subsystem performance was nominal throughout the mission. No in-flight anomalies were identified during the review and analysis of the data.

The inertial measurement units (IMUs) performed satisfactorily throughout the mission. Only one adjustment of the on-board IMU accelerometer compensations was performed for each unit during the flight. No drift compensations were required. The flight control system (FCS) checkout was performed using APU 1. The FCS performed nominally during the checkout.

Sensor data were incorporated into the onboard navigation state vector at the expected times. Drag measurement processing started at approximately 233,900 feet and ended at approximately 84,200 ft. TACAN station acquisition occurred at approximately 154,300 ft. The air data transducer assembly (ADTA) data incorporation began at 81,900 ft and continued to approximately 17,400 ft. All sensor measurement residuals and residual ratio values were nominal with no data editing observed. The backup flight system navigation data also exhibited similar characteristics to the primary flight system. The postflight error analysis has shown a good comparison between the primary flight system state vector and the backup flight system state vector.

Displays and Controls Subsystem

The displays and controls subsystem performed nominally throughout the mission. One in-flight anomaly was identified in the data and from crew comments, and the anomaly is discussed in the following paragraph.

The forward starboard floodlight failed to illuminate when the light was switched on at 271:20:28 G.m.t. (02:17:53 MET). The crew confirmed that the starboard floodlight was not illuminated (Flight Problem STS-86-V-04). The mid power control assembly (MPCA) main B current plots indicated a 1.5-ampere increase and that is the nominal current draw by the floodlight electronics assembly (FEA). The floodlight power switch was recycled and the data again showed no signature of the light illuminating. The floodlight had been successfully used during payload bay door opening earlier in the mission. The postflight inspection revealed a cracked bulb in the floodlight assembly.

Communications and Tracking Subsystems

The communications and tracking subsystems performed satisfactorily throughout the mission.

One minor closed circuit television (CCTV) camera problem was noted and it is discussed in the Government Furnished Equipment/Flight Crew Equipment section of this report.

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation (OI) and modular auxiliary data system (MADS) operated satisfactorily throughout the mission. No in-flight anomalies or significant problems were noted during the mission.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed satisfactorily throughout the mission. No in-flight anomalies were noted in the review of the data and inspection of the hardware. The landing and braking parameters for the mission are shown in the table on the following page.

LANDING AND BRAKING PARAMETERS

Parameter	From threshold, ft	Speed, keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	2489.5	193.4	-3.8	N/A
Nose gear touchdown	5518.5	158.8	N/A	5.19
Brake initiation speed		66.3 knots		
Brake-on time		51.6 seconds		
Rollout distance		11956.3 feet		
Rollout time		82.12 seconds		
Runway		15 (Concrete) KSC		
Orbiter weight at landing		214,726.4 lb		
Brake sensor location	Peak pressure, psia	Brake assembly	Gross energy, million ft-lb	
Left-hand inboard 1	585.4	Left-hand inboard	10.48	
Left-hand inboard 3	585.4			
Left-hand outboard 2	483.4	Left-hand outboard	6.57	
Left-hand outboard 4	483.4			
Right-hand inboard 1	579.4	Right-hand inboard	7.57	
Right-hand inboard 3	579.4			
Right-hand outboard 2	571.2	Right-hand outboard	6.74	
Right-hand outboard 4	571.2			

The tires exhibited no ply undercutting and were in good condition for a landing on the SLF runway with a crosswind that data from the wind towers along the runway showed to be ranging from 6 knots to 14 knots.

The ET/Orbiter separation devices (EO-1, EO-2, and EO-3) functioned normally. No ordnance fragments were found on the runway beneath the cavities. The EO-2 and EO-3 retainer springs were in their nominal configuration. Two clips were missing from the EO-2 fitting "salad bowl". Virtually no umbilical closeout foam or white room temperature vulcanizing (RTV) dam material adhered to the umbilical plate near the LH₂ recirculation line disconnect.

Integrated Vehicle Heating and Thermal Interfaces

The prelaunch thermal interface purges were normal with no problems noted. The ascent aerodynamic and plume heating was normal. The entry aerodynamic heating on the SSME nozzles was higher than normal (metal blued); however, the nozzles met material-hardness test requirements.

Thermal Control Subsystem

The thermal control subsystem (TCS) performance was nominal with all temperatures being maintained within nominal limits throughout the mission. The loss of WSB 3 B heater occurred late in the flight (Flight Problem STS-86-V-06). The loss of the heater did not adversely impact the mission.

The OMS oxidizer high-point bleed line system B heater, which has a higher range thermostat was instrumental in precluding the violation of the quick disconnect low-certification thermal limit while in a potentially constraining attitude.

Aerothermodynamics

The boundary layer transition was symmetrical and MADS data showed boundary layer transition from laminar to turbulent flow occurred at Mach 10.8 and 1146 seconds after entry interface. The acreage heating was normal. A gap filler was protruding 0.30 inch (near the vehicle centerline) and this was the probable cause of the early transition.

Acreage heating was higher than normal as manifested by the high structural temperatures, but the temperatures were within certification limits. Numerous tile repairs were degraded (pulled away from the tiles) and will require replacement prior to the next flight of this vehicle.

Local heating was overall normal, but the thermal barriers around the ET attachment-doors were thermally stressed and will require replacement. Also, the gap filler between the nose cap and the chin panel will require replacement prior to the next flight.

Thermal Protection Subsystem and Windows

The thermal protection system (TPS) and windows performed nominally with no in-flight anomalies identified. Entry heating was higher than expected based on structural temperature rise data. MADS data showed transition to occur at 1146 seconds after entry interface.

There was no significant change to the thermal barrier between the nose cap and the chin panel. Also, there was no subsurface flow observed. Several window carrier plates had minor damage. Repairs will be made to all damaged areas.

The Orbiter thermal protection system (TPS) sustained a total of 129 hits (damage sites) of which 31 had a major dimension of 1 inch or larger. The total number of hits and their distribution, shown in the following table, does not include the numerous hits on the base heat shield that are attributed to the SSME vibration/acoustics, exhaust plume recirculation, and the flame arrestment sparkler system. Based on data from the postflight debris inspection team reports as well as the comparison with statistics from 71 previous flights of similar configuration, the total number of damage sites was greater than average and the number of damage sites that were 1 inch or larger were significantly greater than average.

TPS DAMAGE SITES

Orbiter Surfaces	Hits > 1 Inch	Total Hits
Lower Surface	27	100
Upper Surface	2	21
Right Side	0	0
Left Side	0	3
Right OMS Pod	0	2
Left OMS Pod	2	3
Total	31	129

The largest lower surface tile damage site was located on the left glove and measured 6.5 inches long by 1.25 inches wide by 0.25 inch maximum depth. This damage site was just one of 26 hits (with 13 larger than 1 inch) from an area to the left of the nose and progressing aft almost to the left main landing gear door - an unusual occurrence. To determine the cause of this extensive damage, the ET/Orbiter umbilical films were reviewed, but because of the night launch, the film provided no useful data. Samples of the damage sites were taken for chemical analysis and the analysis is continuing.

The damage sites around and aft of the LH₂ and LO₂ ET/Orbiter umbilicals were greater than usual in size and quantity. The damage was most likely caused by impacts from umbilical ice or shredded pieces of umbilical purge material flapping in the airstream.

One lower surface damage site may have been caused by a micrometeorite or on-orbit debris impact. The 1-inch diameter damage site featured a 0.25-inch diameter by 0.25-inch deep cavity perpendicular to the tile outer mold line.

The SSME dome-mounted heat shield (DMHS) closeout blankets were generally in good condition. However, a blanket panel on SSME 1 was torn and frayed at the 5 o'clock to 6 o'clock position.

Hazing and streaking of forward-facing Orbiter windows was typical. Damage sites on the window perimeter tiles was noticeably less than usual in quantity and size. A piece of a forward RCS thruster-paper cover was wedged between window 5 and the perimeter tiles.

RENDEZVOUS OPERATIONS

The rendezvous operations were nominal and the maneuvers were performed with precision.

EXTRAVEHICULAR ACTIVITY

A highly successful 5 hour and 1 minute extravehicular activity (EVA) was completed by Astronaut Scott Parazynski and Cosmonaut Vladimir Titov, and the life support equipment performed satisfactorily with no anomalies noted. In preparation for the EVA, the airlock depressurization began at 274:17:15 G.m.t. (05:14:40 MET) and was terminated at 274:17:32:29 G.m.t. (05:14:58:10 MET) without any problems. The EVA began when the crew members placed their EMU power switch to the battery position at 274:17:29 G.m.t. (05:14:54 MET).

At the beginning of the EVA, the EV1 crewmember reported that the starboard safety tether reel would not retract (Flight Problem STS-86-X-01). He reported that there was some tension when pulling the wire out of the reel, the lock/unlock lever moved freely in either direction, and the plunger at the base of the lock/unlock lever was not visible. The reel was stowed in the airlock and returned to the crew cabin at the end of the EVA. Following the EVA, the crew reported that the reel began functioning normally after being in the cabin approximately 15 minutes. The plunger at the base of the lock/unlock lever was visible. The most probable cause of the problem is a potential interference at the brake pivot due to contamination or thermal effects. No acceptance thermal test is currently required for safety tethers (qualified at -110 °F). Egress was in a cold attitude during a night pass.

During the EVA, four Mir Environmental Effects Payload (MEEP) experiment packages were retrieved from the Mir Space Station. All four packages were transferred to the payload bay where the packages were attached for entry. A minor fit problem was encountered with carrier 2, but it was resolved satisfactorily. In addition, a Russian solar array cap was transferred to the docking module, and the International Space Station (ISS) EVA hardware that was sponsored by DTO 671 was evaluated. This included the operational configuration of the simplified aid for EVA rescue (SAFER), common foot restraints and safety tethers.

The EVA ended with the start of repressurization at 274:22:30:02 G.m.t. (05:19:55:02 MET).

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

All Government furnished equipment (GFE)/flight crew equipment (FCE) performed nominally during the mission with the one minor exception noted in the following paragraph.

The closed circuit television (CCTV) camera A image exhibited a pinkish hue. This condition occurred once during the mission. The White Sands Test Facility verified that the same image-hue was present on their equipment. This demonstrated that the image probably originated from the camera and not from any ground processing equipment.

CARGO INTEGRATION

The cargo integration hardware performance was nominal throughout the mission with no in-flight anomalies or significant problems noted.

DEVELOPMENT TEST OBJECTIVE/DETAILED SUPPLEMENTARY OBJECTIVE

DEVELOPMENT TEST OBJECTIVES

DTO 259 - Tuned Notch Filter Flight Test - This Development Test Objective (DTO) was not performed because the initial analysis of the RME 1317 MiSDE Joint Operations tests using both the Atlantis and Mir thrusters indicated a potential shift of the major stack frequency.

DTO 312 - ET TPS Performance (Method 1) - Crew hand-held photography of the External Tank (ET) provided 37 views of the ET using the 35 mm camera and 400 mm lens. The sides, nose, and the aft dome of the ET were imaged. The film exposure and focus were good. The first picture of the ET was taken approximately 45.5 minutes after liftoff, and the last picture was taken approximately 14.5 minutes later.

The size of the ET was very small (0.2 mm) as the distance between the Orbiter and ET was 14.1 km, and this hindered the analysis of the ET. The tank tumble rate was calculated to be approximately 4.7 deg/sec. No unusual conditions were noted, and the normal aerodynamic-heating marks were present on the ET thermal protection subsystem. The ET separation velocity and tank roll rate were not determined.

DTO 671 - EVA Hardware for Future Scheduled EVA Missions - Test 14 - On flight day 7, Scott Parazynski and Vladimir Titov performed a 5-hour 1-minute EVA. During the EVA, four MEEP experiments were retrieved, and the Russian solar array cap was transferred to the docking module. In addition, International Space Station (ISS) EVA hardware that was sponsored by DTO 671 was evaluated. This included the operational configuration of the simplified aid for EVA rescue (SAFER), common foot restraints and safety tethers. The results of the evaluation will be presented in separate documentation.

DTO 700-9A - Orbiter Evaluation of TDRS Acquisition in Despreader Bypass Mode - Activities were performed on flight day 7 during orbits 113 and 114. Real-time observations indicated that the Tracking and Data Relay Satellite (TDRS) acquisition was achieved in about eight seconds. This is consistent with acquisition on previous flights as well as expectations for STS-86. The results will be presented in separate documentation.

DTO 700-10 - Orbiter Space Vision System Flight Video Taping - No specific activities were required for this DTO. However, appropriate video taping was accomplished during the DTO 1118 video-taping activities to satisfy the requirements of DTO 700-10.

DTO 700-12 - Global Positioning System/Inertial Navigation System [Configuration A (Litton GPS/INS)] - The Global Positioning System/Inertial Navigation System (GPS/INS) equipment and a data recording PGSC were activated and verified to be operating correctly as a part of launch countdown activities. At launch, the GPS/INS was automatically switched to the navigation mode. Preliminary analysis of the ascent data indicates good GPS/INS performance. Downlink of the first on-orbit data take indicated that the GPS solution was good, but the GPS/INS blended solution was in error by several miles. Additionally, the attitude solution was found to be grossly in error.

Fuel cell amperes indicated an 80-ampere spike for 0.3 second at 269:07:40 G.m.t. (00:05:05 MET). Data indicate that the load was probably on main bus B. Items powered directly from the main buses are the crew cabin panel buses, which includes the utility outlets, the middeck utility panel (MUP), and the power reactant storage and distribution (PRSD) tank heaters. The crew reported that circuit breaker CB4 on the MUP was open. CB4 supplied power to the two payload and general support computers (PGSCs) for the GPS/INS DTO 700-12. A continuity check of the Y-cable providing power to the computers yielded nominal results. After checks of the Orbiter power jack to determine the cause of the CB4 trip showed no problem, the crew reset CB4 and verified correct voltages from the power outlet.

Multimeter measurements taken by the crew indicated that the DTO 700-12 PGSC had an internal thermal fuse that was opened. An IFM procedure was uplinked to the crew to provide power to the PGSC via the external-fuse interface. This method of powering the PGSC would bypass the blown thermal fuse and still provide a fused power supply by using an IFM breakout box with 5-ampere fuses installed. However, this procedure was unsuccessful in recovering the PGSC.

A second IFM procedure was developed to configure one of the trajectory control sensor (TCS) PGSCs for use with DTO 700-12. The crew performed the procedure to recover a PGSC for DTO 700-12 by converting a TCS PGSC (STS 4) to the DTO configuration. After completing the procedure, data read back by the crew showed that the attitude was incorrect. Later in the mission, a procedure to verify the assumed failure condition of the original DTO 700-12 PGSC, an open thermal fuse, was performed. Resistance measurements were obtained between various points on the power connector and fuse holder, but these measurements did not confirm the failure condition of the PGSC. Therefore, the original DTO 700-12 PGSC was stowed for remainder of the flight.

The crew completed a third IFM procedure to set up the entry configuration for the PGSC (STS 4) used for DTO 700-12 (Litton GPS/INS). The IFM involved pre-routing cables and assembling the thermocouple/multimeter configuration for temperature monitoring (since the STS 4 PGSC does not have a thermal fuse). The procedure had Mission Specialist (MS) 4 monitoring the temperature of the PGSC in locker MA16D during entry via a multimeter attached to the MS4 seat. The PGSC temperature was checked every 30 minutes up to ignition for the deorbit maneuver, then every 15 minutes through landing with a final reading at wheels stop. Had the temperature exceeded 140 °F or had the temperature transducer become debonded from the PGSC (indicated by a temperature decrease), power to the PGSC would have been removed. The DTO 700-12 (Litton unit) PGSC was repowered for the flight day 12 deorbit and entry. Data were recorded by the PGSC during the entry phase with no thermal problems indicated. The data were of good quality; however the assessment of the data proved that the GPS/INS was not operating properly during entry.

DTO 700 -13A - Signal Attenuation Effects of ET During Ascent - Activities were performed during the first 60 seconds of ascent. Real-time observations indicated no communication performance degradation. Also, analysis of the Operational Data Reduction Center (ODRC) data indicates that the attenuation was not as severe at the STS-86-specific look angle.

DTO 700-15 - Space Integrated Global Positioning System/Inertial Navigation System - The Space Integrated Global Positioning System/Inertial Navigation System (SIGI) equipment and a data recording PGSC were activated and verified to be

operating correctly as a part of launch countdown activities. At launch, the SIGI was automatically switched to the navigation mode. Preliminary analysis of the ascent data indicates good SIGI performance.

Fuel cell amperes indicated an 80-ampere spike for 0.3 second at 269:07:40 G.m.t. (00:05:05 MET). Data indicate that the load was probably on main bus B. Items powered directly from the main buses are the crew cabin panel buses, which includes the utility outlets, the MUP, and the PRSD tank heaters. The crew reported that circuit breaker CB4 on the MUP was open. CB4 supplied power to the PGSC for the SIGI.

The investigation into the PGSC used for DTO 700-15 showed problems to be present in the PGSC. Multimeter measurements taken by the crew indicated that the DTO 700-15 PGSC had a shorted condition between the power plug and the chassis ground. An IFM procedure was uplinked to the crew to provide power to the PGSC via the external-fuse interface. This method of powering the PGSC would bypass the power plug anomaly and still provide a fused power supply by using an IFM breakout box with 5-ampere fuses installed. The IFM procedure was performed, and power was successfully restored to the DTO 700-15 PGSC. Although data were subsequently acquired from the DTO 700-15 and the PGSC hardware was considered functional, the GPS-only solution was valid but the INS-only and the blended GPS/INS solutions were in error.

Although the SIGI unit continued to indicate good navigation status via the four-satellite tracking discrete, analysis of the data revealed a problem in the pure INS and blended solutions of the SIGI. To reset these solutions, it was necessary to power off the SIGI and reinitialize using the contingency cold-start procedure. During the PGSC repowering portion of the procedure, the 5-ampere fuse in the breakout box opened. Following replacement of the fuse, the cold-start was successfully completed and the SIGI GPS discrete immediately indicated that it was tracking four satellites.

Analysis of data downlinked after the first SIGI cold-start revealed that the SIGI-blended and the INS-only solutions still were not correct. Latency in the data used for the cold-start, combined with previously undetected errors in the cold-start code caused the initialization of the INS to be significantly different from the GPS solution. A new cold-start executable was uplinked and installed on the SIGI PGSC. During the course of this procedure, a power cycle was made on the PGSC, and this caused the 5-ampere fuse in the breakout box to open. The crew changed the fuse and attempted to repower the PGSC. The new fuse opened as well. The decision was made to replace the 5-ampere fuse with a 7.5-ampere fuse. The PGSC then powered on successfully. The cold-start program was completed, and the four-satellite tracking bit turned on within 3 minutes. An attitude reinitialization on SIGI was successfully completed, and the data from the cold-start as well as from several on-orbit data takes were recorded after undocking. The DTO 700-15 PGSC was powered off and stowed for entry. The SIGI unit was powered for entry, and data were collected.

DTO 700-16 - S-Band Sequential Still Video - STS-86 was the first flight of the S-band Sequential Still Video (SSV) system, which provided continued video downlink during Ku-band communication outages. The SSV was used during the mission to provide coverage of rendezvous and docking, the EVA, the Mir fly-around, cargo transfers and other general video scenes for downlink. The SSV was the primary video source during the rendezvous and docking time-frame. The system was used during approximately one-half of the EVA when the Ku-band system was in blockage. The system proved its utility during the EVA by allowing the ground to see a crew-tether problem minutes

before the Ku-band video was available. The SSV video was broadcast on NASA TV and subsequently to the world-wide press covering STS-86.

The SSV system performed well during the mission and provided useful mission support. Some engineering problems were noted with the system, such as how it handled communications dropouts. Future design changes will be implemented to improve the performance in both areas.

DTO 805 - Crosswind Landing Performance - During the landing time-frame, crosswinds were present. Analysis of the data can not confirm that the conditions satisfied the requirements of the DTO.

DTO 1118 - Photographic and Video Survey of Mir Space Station (Configuration A and B) - The ground-based video survey of Mir was conducted by a ground controller while the crew was asleep on flight days 3 through 5. Detailed coverage of the Mir surfaces was successfully obtained using the payload bay cameras. Video during the RME 1317 MiSDE Joint Operations Mir thruster firings was obtained but may be of little value since the Mir was in darkness at the time. Additional fly-around photographic coverage was obtained of selected Kvant-2 and Mir base block surfaces in support of Mir EVA planning.

Also, a rapid response team was formed and developed a procedure to vent a small amount of Mir air into the damaged Spektr module to observe and record subsequent events that might indicate the location of the leak caused by the Progress collision. The procedure included the number and type of imagery equipment, as well as lighting and fly-around timing requirements to increase the probability of obtaining good imagery. The photographic survey and fly-around were conducted on flight day 9 after the Orbiter undocked from the Mir. Video imagery were obtained of the Spektr module during the venting event and at least two particles were noted in the vicinity of the +Z B-side of the module. Additional photographic analysis of all video products during the post-flight period will attempt to determine the number and trajectory of the visible particles.

DTO 1213 - Station Docking Target Evaluation - The bag containing the target and cross was transferred to the Mir as planned. The Mir Commander subsequently installed the docking target onto the docking module hatch. The target and cross were in place on the outside of the docking module hatch when Atlantis separated from the Mir.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 207 - Adaptation to Linear Acceleration after Space Flight - This Detailed Supplementary Objective (DSO) was comprised of only preflight and postflight activities that were completed.

DSO 497 - Effects of Microgravity on Cell Mediated Immunity and Reactivation of Latent Viral Infections - This DSO was comprised of only preflight and postflight activities that were completed.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

The launch photography consisted of 24 launch videos and nineteen 16-mm and 35-mm cameras. A review of all of these films showed no anomalies or significant events. Initial reports indicated threshold-level lateral accelerations that were attributed to possible holddown post stud hang-up. A detailed review of the stud releases showed no evidence of stud hang-up.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

No requirements or requests for review and analysis of on-orbit photography were made.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

Twelve videos of landing were reviewed and no anomalous conditions or events were noted during the review.

TABLE I.- STS-86 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU Activation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	269:02:29:29.167 269:02:29:33.502 269:02:29:37.801
SRB HPU Activation ^a	LH HPU System A start command LH HPU System B start command RH HPU System A start command RH HPU System B start command	269:02:33:51.100 269:02:33:51.260 269:02:33:51.420 269:02:33:51.540
Main Propulsion System Start ^a	ME-3 Start command accepted ME-2 Start command accepted ME-1 Start command accepted	269:02:34:12.458 269:02:34:12.577 269:02:34:12.697
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	269:02:34:19.000
Throttle up to 104 Percent Thrust ^a	ME-2 Command accepted ME-3 Command accepted ME-1 Command accepted	269:02:34:22.736 269:02:34:22.745 269:02:34:22.777
Throttle down to 67 Percent Thrust ^a	ME-2 Command accepted ME-3 Command accepted ME-1 Command accepted	269:02:34:53.456 269:02:34:52.465 269:02:34:52.498
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	269:02:35:09
Throttle up to 104 Percent ^a	ME-2 Command accepted ME-3 Command accepted ME-1 Command accepted	269:02:35:20:977 269:02:35:20.985 269:02:35:21.018
Both RSRM's Chamber Pressure at 50 psi ^a	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	269:02:36:16.680 269:02:36:16.720
End RSRM ^a Action ^a Time	LH SRM chamber pressure mid-range select RH SRM chamber pressure mid-range select	269:02:36:19.350 269:02:36:19.420
SRB Physical Separation ^a	LH rate APU turbine speed - LOS RH rate APU turbine speed - LOS	269:02:36:22.000 269:02:36:22.000
SRB Separation Command	SRB separation command flag	269:02:36:22
Throttle Down for 3g Acceleration ^a	ME-2 command accepted ME-1 command accepted ME-3 command accepted	269:02:41:48.665 269:02:41:48.665 269:02:41:48.669
3g Acceleration	Total load factor	269:02:41:48.6
Throttle Down to 67 Percent Thrust ^a	ME-2 command accepted ME-1 command accepted ME-3 command accepted	269:02:42:43.386 269:02:42:43.386 269:02:42:43.390
SSME Shutdown ^a	ME-2 command accepted ME-1 command accepted ME-3 command accepted	269:02:42:49.866 269:02:42:49.866 269:02:42:49.870
MECO	MECO command flag MECO confirm flag	269:02:42:51 269:02:42:51
ET Separation	ET separation command flag	269:02:43:10

^aMSFC supplied data

**TABLE I.- STS-86 SEQUENCE OF EVENTS
(Continued)**

Event	Description	Actual time, G.m.t.
APU Deactivation	APU-1 GG chamber pressure APU 2 GG chamber pressure APU 3 GG chamber pressure	269:02:49:14.562 269:02:49:37.115 269:02:49:53.608
OMS-1 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
OMS-1 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	
OMS-2 Ignition	Right engine bi-prop valve position Left engine bi-prop valve position	269:03:16:09.2 269:03:16:09.3
OMS-2 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	269:02:17:57.9 269:02:17:58.0
Payload Bay Doors (PLBDs) Open	PLBD right open 1 PLBD left open 1	269:04:06:28 269:04:07:28
OMS-3 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	269:05:59:09.6 269:05:59:09.7
OMS-3 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	269:06:00:08.8 269:06:00:08.9
OMS-4 Ignition	Right engine bi-prop valve position Left engine bi-prop valve position	269:17:26:15.1 269:17:26:15.2
OMS-4 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	269:17:26:51.1 269:17:26:51.2
OMS-5 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	270:15:59:25.6 270:15:59:25.7
OMS-5 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	270:15:59:52.2 270:15:59:52.3
Ring Capture	Capture	270:19:57:46
Docking	Docking ring final position	270:20:06:05
Airlock Depressurization	Airlock differential pressure	274:17:32:29
Airlock Repressurization	Airlock differential pressure	274:22:30:02
Undocking	Undocking complete	276:17:28:15
OMS-6 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	276:22:25:27.2 276:22:25:27.3
OMS-6 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	276:22:25:46.8 276:22:25:46.9
Flight Control System Checkout Circulation Pump Start Circulation Pump Stop	APU 1 GG chamber pressure APU 1 GG chamber pressure	277:15:49:40.072 277:15:56:00.921
OMS-7 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 277:20:32:14.2
OMS-7 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 277:20:32:24.4
First Payload Bay Door Closure	PLBD left close 1 PLBD right close 1	278:19:13:11 278:19:16:34
Second Payload Bay Door Opening (BFS)	PLBD right open 1 PLBD left open 1	278:23:42:26 278:23:43:45
Second Payload Bay Door Closure	PLBD left close 1 PLBD right close 1	279:18:04:32 279:18:06:30
APU Activation for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	279:20:43:00.926 279:21:10:34.781 279:21:10:45.848

**TABLE I.- STS-86 SEQUENCE OF EVENTS
(Concluded)**

Event	Description	Actual time, G.m.t.
Deorbit Burn Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	279:20:47:45.3 279:20:47:45.3
Deorbit Burn Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	279:20:51:00.7 279:20:51:00:9
Entry Interface (400K feet)	Current orbital altitude above	279:21:23:29
Blackout end	Data locked (high sample rate)	No blackout
Terminal Area Energy Mgmt.	Major mode change (305)	279:21:48:39
Main Landing Gear Contact	LH MLG inboard tire pressure 2 RH MLG outboard tire pressure 2	279:21:55:09 279:21:55:09
Main Landing Gear Weight on Wheels	RH main landing gear weight on wheels LH main landing gear weight on wheels	279:21:55:12 279:21:55:14
Nose Landing Gear Contact	NLG RH tire pressure 1	279:21:55:19
Nose Landing Gear Weight On Wheels	NLG weight on wheels 1	279:21:55:19
Drag Chute Deployment	Drag chute deploy 1 CP volts	279:21:55:22.1
Drag Chute Jettison	Drag chute jettison 1 CP Volts	279:21:55:56.7
Wheel Stop	Velocity with respect to runway	279:21:56:31
APU Deactivation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	279:22:12:22.591 279:22:12:36.194 279:22:12:47.438

TABLE II.- SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-86-V-01	Fuel Cell 2 Substack 1 Differential Volts Transient	269:02:35 G.m.t. 00:00:01 MET 86RF03 IPR 92V-0001	<p>Starting at about 269:02:35:21 G.m.t. (00:00:01:02 MET), the fuel cell 2 substack 1 cell performance monitor (CPM) differential voltage (ΔV) output exhibited an unusual increase. The substack 1 ΔV increased into the 300 to 500 mV range for a period of about 15 seconds (500 mV for two seconds), then decreased into the 100 to 200 mV range for about twenty seconds. The entire event lasted about 1 minute and the substack 1 ΔV reading prior to and after the event was in the 6 to 8 mV range. During this event, no anomalous indications were seen in the fuel cell 2 substack 2 or 3 ΔV indications, and no other fuel cell parameters indicated that there was a fuel cell problem.</p> <p>Because of this ascent event, main buses A and B were bus tied at 269:02:46 G.m.t. (00:00:11 MET) and, as a precaution, these fuel cells remained tied until deorbit preparations. After the first landing attempt was waved-off, the buses were retied and the tie was broken during the following day's deorbit preparations. The CPM performed nominally for the remainder of the mission, and the fuel cell stack 1 ΔV remained in the 2 to 8 mV range.</p> <p>The data indicate that this event was most probably caused by an instrumentation problem and was not the result of a physical or chemical problem within the fuel cell substack.</p> <p>KSC: An instrumentation test was performed on the vehicle and no problems were found. The fuel cell was returned to the vendor for troubleshooting.</p>
STS-86-V-02	Primary RCS Thruster L3D Failed Off	269:02:43 G.m.t. 00:00:09 MET CAR 86RF01 IPR 92V-0009	<p>Primary RCS thruster L3D failed off during its first commanded firing following ET separation. During the firing, the chamber pressure did not rise above 4 psia and the thruster was deselected due to this low chamber pressure (P_c) indication. The thruster was not used for the remainder of the mission.</p> <p>The L3D injector temperature data profile was indicative of a normal firing, thus suggesting that the thruster did fire. The data also showed that the L3D P_c slowly decreased from approximately 18 psia to 4 psia over a 7-minute period during ascent, whereas the drop should have occurred in approximately 1.5 minutes. Note that even though the 18 psia ground indication was higher than normal, it was discounted as a problem because it appeared to be an instrumentation bias and the LCC allows ambient ± 10 psia. The indicated L3D P_c remained in the 3 to 4 psia range throughout the mission indicating that there was a bias in the measurement. Following landing, the L3D P_c remained at the 4 psia for just over an hour, after which it slowly rose to approximately 15 psia over an 18-minute period. The data from ascent and entry and the fall-off during the ET separation firing may be the result of a plugged P_c tube.</p> <p>KSC: A boroscope inspection of the thruster chamber will be performed. Since the OV-104 vehicle is going to OMDP, the LP03 pod will be sent to the Hypergolics Maintenance Facility (HMF) for its OMDP and the inspection will be performed in November 1997. All thrusters are scheduled to be removed and sent to White Sands Test Facility (WSTF) for normal OMDP processing. Therefore, any additional investigation of this failure that may be necessary will be performed at the WSTF.</p>

TABLE II.- SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-86-V-03	APU 2 Gas Generator Bed Heater B High Cycle-Frequency	274:22:04 G.m.t. 05:19:29 MET CAR 86RF04	<p>Following the APU heater reconfiguration, the APU 2 gas generator (GG) bed system B heater cycled at a high frequency. Proper GG bed temperature was maintained in the nominal 360 to 425 °F control band. As a result of the high-frequency cycling, the injector temperature remained nearly constant at 359 °F following the heater reconfiguration. A signature similar to the one seen on this mission has been seen previously on this APU (s/n 402). It is believed to be caused by the GG bed temperature sensor, which is used by the APU controller to control the heater, being very close to the B heater. This results in very frequent heater cycling and a dithering appearance in the injector temperature. This frequency has increased since it was first noted on STS-50 (seven flights).</p> <p>KSC: The APUs were previously scheduled to be removed after this flight (OV-104 OMDP) and returned to the APU vendor. Special testing will be performed on the heater to determine the cause of the signature. It will then be determined if corrective action is required.</p>
STS-86-V-04	Forward Starboard Floodlight Failed to Illuminate	271:20:28 G.m.t. 02:17:53 MET CAR 86RF02 IPR 92V-0002	<p>The forward payload bay floodlights were powered on at approximately 271:20:28 G.m.t. (02:17:53 MET). The forward starboard floodlight (no. 2) failed to illuminate. The crew confirmed that the starboard floodlight was not illuminated, but the port floodlight was illuminate. A data plot of the mid main bus B currents indicated no signature of the floodlight activation. A 1.5 ampere increase indicative of the floodlight electronics assembly (FEA) current draw was seen. The crew cycled the forward starboard floodlight switch, and the data again showed no signature of the floodlight turning on. The floodlight had been used successfully during payload bay door opening. Floodlights 1 through 5 are the new design. The FEA 2, which powers floodlight 2, is also the new design.</p> <p>KSC: A visual inspection of the floodlight revealed a cracked bulb. The floodlight will be replaced.</p>
STS-86-V-05	Pressure Control System 1 14.7 psia Regulator Early Flow Termination	275:02:40 G.m.t. 06:00:06 MET CAR 86RF07	<p>A repressurization of the combined Orbiter/Mir stack was started at 275:01:52 G.m.t. (05:23:18 MET) using pressure control system (PCS) 1 providing Nitrogen and PCS 2 providing oxygen. The initial pressure was approximately 12.6 psia. The N₂ flow rate began to rapidly decrease 43 minutes later, with the cabin pressure at approximately 14.3 psia, as the regulator transitioned from high flow to low flow (should occur at 14.6 psia). The repressurization was terminated by the crew after 48 minutes of N₂ flow, and the crew reported that ice had formed on the pressure control system panel. Following a crew sleep period, the stack repressurization was resumed using PCS 2. This repressurization was completed nominally in 32 minutes with the pressure increasing to 14.62 psia, which is the control pressure for the PCS 2 14.7 psia cabin regulator. The PCS 1 regulator was then enabled and the repressurization continued nominally to 14.7 psia, which is the control pressure for the PCS 1 14.7 psia regulator.</p> <p>It is believed that chilling of the regulator as a result of the long-duration high flow (approx. 187 lb/hr) caused an early termination from high flow to low flow. At the time of the event, the nitrogen supply tank temperatures were in the -10 to -50 °F range. Two possible explanations have been</p>

TABLE II.- SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-86-V-05 (Continued)			<p>hypothesized for the early transition. The first is that the bellows in the high-flow portion of the regulator lost elasticity at the low temperatures which caused the poppet to return to its original (closed) position. The second is that chilling of the reference chamber in the low-flow portion of the regulator caused the regulator set point to change.</p> <p>KSC: A postflight N₂ sample was taken as well as a test performed to verify the high-flow capability of the regulator. The moisture content of the N₂ was well within specification and high-flow capability of the regulator was verified. Testing will also be performed at JSC to better understand the operation of the cabin regulators and to verify the emergency capability of the 8-psia regulators.</p>
STS-86-V-06	WSB 3 Vent Heater Failure on the B Controller	278:21:59 G.m.t. 09:19:25 MET CAR 86RF05 UA-4-A0039	<p>At 278:21:59 G.m.t. (09:19:25 MET) during the time period between the first and second landing opportunities, the WSB 3 vent temperature no. 2 went off-scale low (122 °F). Nominally, the vent heater should have cycled back on at around 145 °F. The system was operating on the B controller at the time, and this signature indicated that the B heater had failed off. The system was switched to the WSB 3A controller at 278:22:28 G.m.t. (09:19:54 MET), and a rise in the vent temperature was observed a short time later. Nominal cycling of the system A vent heater was observed. The B vent heater was tried again following the wave-off of the first landing attempt as well as on entry day. In both instances, the B vent heater remained failed.</p> <p>This problem also occurred just prior to the entry deorbit maneuver for the STS-76 mission, when the WSB 3 vent temperature went off-scale low with WSB 3 on controller B. The system was switched to the WSB 3 A controller, and after approximately 30 minutes and nominal cycling on the A controller, the system was switched back to the B controller. Nominal cycling of the B vent heater was observed for the remainder of the flight. The problem was not found during postflight troubleshooting and the next mission was flown in the as-is condition. The problem had not repeated until the STS-86 occurrence.</p> <p>KSC: Verification testing determined that the heater was still failed. Troubleshooting on this problem will be performed when the vehicle is in Palmdale.</p>

TABLE III.- EVA EQUIPMENT PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-86-X-01	EVA Safety Tether Reel Failure	274:17:44 G.m.t. 05:15:09 MET VJCS-4-20-0432	<p>At the beginning of the EVA, the EV1 crewmember reported that the starboard safety tether would not retract. EV1 reported that some tension was present when pulling the wire out of the reel, the lock/unlock lever moved freely in either direction, and the plunger at the base of the lock/unlock lever was not visible. The reel was stowed in the airlock and returned to the crew cabin at the end of the EVA. Following the EVA, the crew reported that the reel began functioning normally after being in the cabin approximately 15 minutes. The plunger at the base of the lock/unlock lever was visible.</p> <p>The most probable cause of the problem is a potential interference at the brake pivot due to contamination or thermal effects. No acceptance thermal test is currently required for safety tethers (qualified at -110 °F). Egress was in a cold attitude during a night pass.</p> <p>As a result of this problem, the three safety tethers (spare already manifested) that will be flown on STS-87 were acceptance thermal tested (-180 °F) at JSC and no problems were noted. The STS-86 hardware was returned to JSC for thermal test, disassembly and inspection. A design change may be required. The corrective action will be determined after hardware disassembly.</p>

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for this mission report, the following list is provided.

1. Flight Requirements Document
2. Public Affairs Press Kit
3. Customer Support Room (CSR) Daily Science Reports, and Final CSR Report
4. Mission Evaluation Room (MER) Daily Reports
5. MER Landing Report
6. MER Problem Tracking List
7. MER Event Times
8. Subsystem Manager Reports/Inputs
9. MOD Systems Anomaly List
10. MSFC Flash Report
11. MSFC Event Times
12. MSFC Interim Report
13. Crew Debriefing comments
14. Shuttle Operational Data Book
15. STS-86 Summary of Significant Events
16. Contractor Reports of Subsystem Operation
17. SSVEO In-Flight Anomaly Lists

ACRONYMS AND ABBREVIATIONS

The following is a list of the acronyms and abbreviations and their definitions as these items are used in this document.

ABS	ammonia boiler system
ADTA	air data transducer assembly
ADV CGBA	Advanced Commercial Generic Bioprocessing Apparatus
APU	auxiliary power unit
ARS	atmospheric revitalization system
ATCS	active thermal control system
B103D	Biochemistry of Three Dimensional Tissue
BSTC-M	Biotechnology Specimen Temperature Controller-Mir
BTR	Biotechnology Refrigerator
CAPE	Canadian Protein Experiment
CCM-A	Cell Culture Module-Configuration A
CCTV	closed circuit television
CPCG	Commercial Protein Crystal Growth
CPM	cell performance monitor
CREAM	Cosmic Radiation Effect and Activation Monitor
CWC	contingency water container
DMHS	dome-mounted heat shield
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔV	differential velocity
ECLSS	Environmental Control and Life Support System
ECO	engine cutoff
EDL	enhanced dynamic load
e.d.t.	eastern daylight time
EGT	exhaust gas temperature
EMU	extravehicular mobility unit
EO	ET/Orbiter
EPDC	electrical power distribution and control
EPOS/EPS	European Proximity Operations Sensor
ESA	European Space Agency
ESC	electronic still camera
ET	External Tank
EVA	extravehicular activity
FCL	Freon coolant loop
FCS	flight control system
FEA	floodlight electronics assembly
FES	flash evaporator system
FPV	flow proportioning valve
ft/sec	feet per second
GAS	Get-Away Special
GG	gas generator
Gh _e	gaseous helium
GH ₂	gaseous hydrogen
G.m.t.	Greenwich mean time

GN ₂	gaseous nitrogen
GO ₂	gaseous oxygen
GPS	Global Positioning System
H ₂	hydrogen
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
IELK	Individual Equipment Liner Kits
IFM	in-flight maintenance
IMU	inertial measurement unit
INS	inertial navigation system
I _{sp}	specific impulse
ISS	International Space Station
IVA	intravehicular activity
km	kilometer
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt/hour
lb	pound
lb/hr	pound/hour
lbm	pound mass
lb/min	pound per minute
LCC	Launch Commit Criteria
LH ₂	liquid hydrogen
LiOH	lithium hydroxide
LMSMS&S	Lockheed Martin Space Mission Systems and Services
LO ₂	liquid oxygen
MADS	Modular Auxiliary Data System
MC	midcourse correction (maneuvers)
MECO	main engine cutoff
MEEP	Mir Environmental Effects Payload
MET	mission elapsed time
MiSDE	Mir Structural Dynamics Experiment
mm	millimeter
MPCA	mid power controller assembly
MPS	main propulsion system
MSX	Midcourse Space Experiment
MUP	middeck utility panel
mV	millivolt
NASA	National Aeronautics and Space Administration
N ₂	nitrogen
NC1-4	rendezvous maneuvers (four)
NCC	corrective combination maneuver
nmi.	nautical mile
NPSP	net positive suction pressure
NSTS	National Space Transportation System (i.e., Space Shuttle Program)
O ₂	oxygen
OCA	Orbiter communications adapter
ODRC	Operational Data Reduction Center
ODS	Orbiter docking system
OI	operational instrumentation

OMDP	Orbiter Maintenance Down Period
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
PAL	protuberance air load
P _c	chamber pressure
PCS	pressure control subsystem
PGSC	payload general support computer
PMBT	propellant mean bulk temperature
ppm	parts per million
PRSD	power reactant storage and distribution
psi	pound per square inch
psia	pound per square inch absolute
psid	pound per square inch differential
RCS	reaction control subsystem
RME	Risk Mitigation Experiment
RME-III	Radiation Monitoring Experiment-III
RSRM	Reusable Solid Rocket Motor
RTV	room temperature vulcanizing (material)
S&A	safe and arm
SAFER	Simplified Air for EVA Rescue
SEEDS-II	Seeds in Space-II
SEU	single event upset
SIGI	Space Integrated GPS/INS
SIMPLEX	Shuttle Ionospheric Modification with Pulsed Local Exhaust
SLF	Shuttle Landing Facility
S/N	serial number
SPSR	Space Portable SpectroReflectometer
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSME	Space Shuttle main engine
SSV	sequential still video
SSVEO	Space Shuttle Vehicle Engineering Office
STS	Space Transportation System
TACAN	tactical air control and navigation
TCS	thermal control subsystem/trajectory control sensor
TDRS	Tracking and Data Relay Satellite
TEHM	thermal electric holding module
TPCS	test of PCS hardware
TPS	thermal protection system/subsystem
WSB	water spray boiler